

3.3 Summary of Probehole Cluster Groupings, Naming Convention, and Preferred Installation Sequence

3.3.1 Probe Naming

Table 9 lists the probes planned for the Type B investigation. If additional probes are placed, the naming conventions described below should be used, if practical. Probes placed during the Type B investigation start off with the following root name: “RWMC-SCI-S-.” The “RWMC” refers to the facility location, the “SCI” refers to the probes as scientific instruments, and the “S” refers to the Type B probes installed in the shallow surface soils (i.e., above the first basalt). The remainder of the individual probe names is given in Table 9. It is expected that the abbreviated name given in Table 6 will be noted in the logbooks used to record activities associated with the Type B probe installation and subsequent sampling. Where vertical placement of a sampling port (i.e., the porous steel of a lysimeter) is recommended based on Type A logging results, the vertical placement is given following the probe name. This is indicated by a footage in parentheses (e.g., [9.5 ft]), following the probe name.

The first part of the site-specific name, prior to the first dash, refers to the focus area, moisture-monitoring network, or general pit number (e.g., DU, MM4, Pit 6). The second part of the name contains up to two digits and refers to the original Type A probe around which the cluster of Type B probes is centered, or is a sequential number for the area in cases where Type B probes are not being placed around original Type A probes (e.g., at the moisture monitoring networks, the SVRs, Pit 5, and Pit 6). The last part of the name is one or two characters referring to probe type and, in cases where multiple probes of the same type are bundled (i.e., nested), is followed by a single digit indicating the vertical placement of the probe. Note that for the soil moisture probes, this code (which refers to vertical placement) is not given in the table. In situations where the tripled soil moisture probe is not used and two probes are used in lieu of one, a digit will be used indicating whether the probe is the deep or shallow probe. Table 10 contains the key that defines the last part of the probe name.

The soil moisture probes will be named as indicated by Table 9. However, these probes often have three sensors placed vertically within the single probe string assembly. The same vertical placement nomenclature described above will be used to define sensor locations within the probe (e.g., 1 = deep and 3 = shallow).

3.3.2 Probe-Installation Sequence

This section describes the preferred sequence for probe installation. It will be used as a general guide only. Factors, such as probe availability and field preferences (e.g., the need to place certain probes first so the rig does not get “boxed in”), may change the suggested sequence described here.

For bundled (i.e., nested) probes of the same type (e.g., tensiometers), the preference is to install the deep probe first and the shallow probe last. This is preferred because if an obstruction of impenetrable material is encountered during installation of the first deep probe, this probe could be completed at the obstruction and be considered a middle or shallow probe. The subsequent probe installed in the bundle could be offset laterally in an attempt to clear the subsurface obstruction.

The general preference for the probe-installation sequence in a cluster is provided below.

- Visual probes
- Tensiometers
- Lysimeters or geochemical probes

Table 9. Breakdown of probehole locations by area and probehole naming.

Instrument/ Location/ Focus	Tensiometer	Soil Moisture Probe	Lysimeters	Vapor Port Probe	Geochemical Probe	Visual Probe
Instruments per probe	1	3 (typical)	1	1	1	1
Probes per bundle	3	1	2	3	1	1
Total sample (measurement) points	90	90	30	63	8	13
Total probe bundles	30	30	15	21	8	13
Pit 4	15	15	4	5	2	5
Volatile organic compound (VOC) focus	743-03-T1 743-03-T2 743-03-T3	743-03-M	743-03-L1 743-03-L2	743-03-VP1 743-03-VP2 743-03-VP3	743-03-G	743-03-V
VOC focus and depleted uranium (DU) focus	743-08-T1 743-08-T2 743-08-T3	743-08-M	743-08-L1 743-08-L2	743-08-VP1 743-08-VP2 743-08-VP3	743-08-G	743-08-V
VOC focus	743-18-T1 743-18-T2 743-18-T3	743-18-M	743-18-L1 743-18-L2	743-18-VP1 743-18-VP2 743-18-VP3		743-18-V
	743-xx-T1 743-xx-T2 743-xx-T3	743-xx-M	743-xx-L1 743-xx-L2	743-xx-VP1 743-xx-VP2 743-xx-VP3		743-xx-V
	743-xx-T1 743-xx-T2 743-xx-T3	743-xx-M		743-xx-VP1 743-xx-VP2 743-xx-VP3		743-xx-V
	743-xx-T1 743-xx-T2 743-xx-T3	743-xx-M				
	MM1-1-T1 MM1-1-T2 MM1-1-T3	MM1-1-M				
	MM1-2-T1 MM1-2-T2 MM1-2-T3	MM1-2-M				
	MM1-3-T1 MM1-3-T2 MM1-3-T3	MM1-3-M				
	MM2-1-T1 MM2-1-T2 MM2-1-T3	MM2-1-M				
	MM2-2-T1 MM2-2-T2	MM2-2-M				

Table 9. (continued).

Instrument/ Location/ Focus	Tensiometer	Soil Moisture Probe	Lysimeters	Vapor Port Probe	Geochemical Probe	Visual Probe
Pit 4 (continued) VOC focus	MM2-2-T3					
	MM2-3-T1	MM2-3-M				
	MM2-3-T2					
	MM2-3-T3					
	MM3-1-T1	MM3-1-M				
	MM3-1-T2					
	MM3-1-T3					
	MM3-2-T1	MM3-2-M				
	MM3-2-T2					
	MM3-2-T3					
	MM3-3-T1	MM3-3-M				
	MM3-3-T2					
	MM3-3-T3					
Pit 5	2	2	2	2	2	1
	Pit5-1-T1	Pit5-1-M	Pit5-1-L1	Pit5-1-VP1	Pit5-1-G	Pit5-1-V
	Pit5-1-T2		Pit5-1-L2	Pit5-1-VP2		
	Pit5-1-T3			Pit5-1-VP3		
	Pit5-2-T1	Pit5-2-M	Pit5-2-L1	Pit5-2-VP1	Pit5-2-G	
	Pit5-2-T2		Pit5-2-L2	Pit5-2-VP2		
	Pit5-2-T3			Pit5-2-VP3		
Pit 6	0	0	0	3	0	1
				Pit6-1-VP1		Pit6-1-V
				Pit6-1-VP2		
				Pit6-1-VP3		
				Pit6-2-VP1		
				Pit6-2-VP2		
				Pit6-2-VP3		
				Pit6-3-VP1		
				Pit6-3-VP2		
				Pit6-3-VP3		
Pit 10	11	11	8	3	2	6
DU focus	DU-10-T1	DU-10-M	DU-10-L1	DU-10-VP1	DU-10-G	DU-10-V
	DU-10-T2		DU-10-L2	DU-10-VP2		
	DU-10-T3		(7.5 ft, 190°)	DU-10-VP3		
DU focus	DU-14-T1	DU-14-M	DU-14-L1	DU-14-VP1		DU-14-V
	DU-14-T2		DU-14-L2	DU-14-VP2		
	DU-14-T3		(8 ft, 65°)	DU-14-VP3		
DU focus	DU-16-T1	DU-16-M	DU-16-L1	DU-16-VP1		DU-16-V
	DU-16-T2		DU-16-L2	DU-16-VP2		
	DU-16-T3		(13.5 ft, 130°)	DU-16-VP3		
			DU-xx-L1			
			DU-xx-L2			

Table 9. (continued).

Instrument/ Location/ Focus	Tensiometer	Soil Moisture Probe	Lysimeters	Vapor Port Probe	Geochemical Probe	Visual Probe
Pit 10 (continued) Am/Np Focus	DU-08-T1 DU-08-T2 DU-08-T3	DU-08-M	DU-08-L1 DU-08-L2 (14.5 ft, 190°)			DU-08-V
Am/Np focus	741-8-T1 741-8-T2 741-8-T3	741-8-M	741-8-L1 741-8-L2 (8 ft, 125°)		741-8-G	741-8-V
Am/Np focus	741-2-T1 741-2-T2 741-2-T3	741-2-M	741-2-L1 741-2-L2 (11.5 ft, 85°) 741-xx-L1 741-xx-L2			741-2-V
	MM4-1-T1 MM4-1-T2 MM4-1-T3	MM4-1-M				
	MM4-2-T1 MM4-2-T2 MM4-2-T3	MM4-2-M				
	MM4-3-T1 MM4-3-T2 MM4-3-T3	MM4-3-M				
	MM4-4-T1 MM4-4-T2 MM4-4-T3	MM4-4-M				
	MM4-5-T1 MM4-5-T2 MM4-5-T3	MM4-5-M				
SVR-12	1	1	1	6	1	0
	SVR12-1-T1 SVR12-1-T2 SVR12-1-T3	SVR12-1-M	SVR12-1-L1 SVR12-1-L2	SVR12-1-VP1 SVR12-1-VP2 SVR12-1-VP3 SVR12-2-VP1 SVR12-2-VP2 SVRxx-2-VP3 SVR12-3-VP1 SVR12-3-VP2 SVR12-3-VP3	SVR12-1-G	

Table 9. (continued).

Instrument/ Location/ Focus	Tensiometer	Soil Moisture Probe	Lysimeters	Vapor Port Probe	Geochemical Probe	Visual Probe
SVR-20	1	1	0	5	1	0
	SVR20-1-T1 SVR20-1-T2 SVR20-1-T3	SVR20-1-M		Note: GSP1 series of VPs is in place, that is why SVR20-2 VP series starts below: SVR20-2-VP1 SVR20-2-VP2 SVR20-2-VP3 SVR20-3-VP1 SVR20-3-VP2 SVR20-3-VP3 SVR20-4-VP1 SVR20-4-VP2 SVR20-4-VP3 SVR20-5-VP1 SVR20-5-VP2 SVR20-5-VP3 SVR20-6-VP1 SVR20-6-VP2 SVR20-6-VP3	SVR20-1-G	

Table 10. Key that defines the last part of the probe name.

ID	Probe Type
T	Tensiometer
M	Soil moisture probe
L	Lysimeter
VP	Vapor port probe
V	Visual probe

ID	Vertical Placement
1	Deep
2	Middle
3	Shallow

- Soil moisture probes
- Vapor ports.

Issues (e.g., availability of probes) may alter the preferred sequence outlined here without significant consequence to the project. Visual probes may be installed first because this probe type is installed into the contact between the waste and underburden or basalt. In addition, video recording through the visual probe may provide valuable information to assist the field team in optimal placement of subsequent instruments (e.g., lysimeters), and tensiometers may then be installed. Using the deep tensiometer to provide depth information about the waste zone and underburden soil interface will give confidence in locating the lysimeter and geochemical probes at that contact. The soil moisture probes could then be installed because enough information regarding the lower contact would be known so that this probe could be installed effectively as a three-sensor unit. The vapor ports should be installed last, if practical. The vapor ports will not function if completed in saturated conditions. Saturated conditions are most likely at the waste zone and underburden contact, or at the underburden and basalt contact. Being able to tag the contact between the waste zone and the underburden soil and then installing the deep vapor port approximately 8 in. (20 cm) above this contact should allow for completion of this probe above the most likely perched water level and ensure that it is functional.

3.4 Probe-Installation Contingency

Probes may not be installed to the depth planned because of several factors, including probes not installed to targeted depths because of encounters with solid items (e.g., solid metallic waste), or the existence of shallower subsurface conditions than expected. Probes may also be installed deeper than planned (i.e., installation of a soil moisture probe below the contact between the waste and underburden soil in areas where information regarding this contact is scarce). Probes may also break or become inoperable during installation.

The following contingencies will be considered when evaluating the conditions described above. Typically, when multiple probes of the same type are being installed in one location, the deep probe will be installed first. If refusal is encountered prior to reaching a desired depth, consideration should be given to completing that probe as one of the shallower probes planned for that location. When that is not possible or where only one of that probe type is being installed at a subject location, consideration for installing another probe will be weighed against probe availability and current financial constraints.

Probes may be installed too deep below suggested completion intervals (i.e., waste to underburden contact). In these cases, it is anticipated that though the targeted depth was exceeded, useful data can still be gathered. It is unlikely that additional probes will be installed in this scenario.

Probes that are broken during installation are expected to be replaced, providing additional probes are available, and considering current financial constraints.

The project manager and project engineer, in consultation with the field crew, will make decisions regarding probe-installation contingencies.

4. SAMPLE DESIGNATION

A systematic 10-character sample identification code will be used to uniquely identify all samples. The uniqueness of the number is required for maintaining consistency and ensuring that no two samples are assigned the same identification code. The INEEL SMO assigns the sample numbers. Quality control samples will have a unique sample number to support a “blind” submittal to the analytical laboratories. The Integrated Environment Data Management System ensures the uniqueness of sample identification.

The unique sample number will be broken down into the following five parts:

- Initial project identifier
- Basic sample origin (either lysimeter or vapor port)
- Sequential sampling event number
- Field quality control identifier
- Bottle code.

The first part of the sample number, a two-character project identifier, has been established as “IP,” for integrated probing project. Care should be taken to ensure that this is clearly recorded as a capital “I” and not the numerical digit “1.” The second part of the sample number will be an “L” for “lysimeter-based water samples” or a “V” for “gas samples originating from vapor ports.” The third part of the number will be a three-digit sequential number starting at 001 and ending through 999, and will be unique to the individual sampling event (i.e., the group of samples collected from a single sampling port [e.g., deep lysimeter]) during the same time period. The next two digits will typically be an “01” or “02” for a regular or field duplicate sample, respectively. The final two characters refer to the bottle code identified in the sample plan tables (see Appendix B).

5. SAMPLING EQUIPMENT AND PROCEDURES

5.1 Physical Sample Collection and Handling

Various EDFs and TPRs describe the design of the systems and detail operations that support successful sample acquisition during this project. This FSP incorporates those EDF and TPR specifications by reference and includes any specifications that were not in the TPRs (e.g., acid types used in sample preservation).

A sample preparation facility (expected to be located in Waste Management Facility [WMF]-601) may be used to support sample preparation and limited analysis (e.g., VOC soil-gas samples collected from vapor ports). The sample preparation facility contains the following items to support collection, preparation, and transportation of samples:

- Radiologically controlled hood to support sample preparation (e.g., splitting water samples from the sample collection vessel to the individual, preserved sample containers)
- Exhaust line to vent exhausted gas from the multigas photoacoustic analyzer (i.e., the unit used to analyze soil-gas samples for VOCs)
- Sample refrigerator to store samples requiring cooling prior to shipment to laboratories
- Sample freezer to store ice for sample temperature control during transport
- Acid cabinet to store acids for sample preservation
- Storage and sampling supplies.

Because of different sample acquisition controls related to different subsurface radiological conditions, two different sampling protocols have been developed for this project: one for samples that require a glove bag, and one for those that do not require a glove bag. The protocols were established to cover the following groups:

- Glove bag collection is required: All water samples collected from lysimeters during this investigation and all gas samples collected from vapor ports located within the pits will require use of a glove bag for initial sample acquisition.
- Glove bag collection is not required: Radioactive gases collected from the SVRs will not require use of glove bags because radioactive particulate contamination is not expected while gas samples are being collected outside of buried waste.

All samples that require glove bag collection in the field are acquired with equipment defined in EDF-ER-239, *OU 7-13/14 Integrated Probing Project Sample Acquisition and Glove Bag Design* (Sifuentes and Moody 2001). This EDF describes the design of the sample acquisition equipment from the manifold located at the probe outlet ports to the delivery of a “lab-ready” split and preserved sample. This EDF includes the design of the glove bags and auxiliary equipment to support sample acquisition. The TPR-1674, “Glove Bag Supported Sample Acquisition from Type B Probes in the SDA,” is used to collect these samples. This TPR includes all aspects of acquiring samples from lysimeters and vapor ports in glove bags in the field. The procedure includes water sample handling activities in the sample preparation facility. The TPR also includes handling soil-gas samples analyzed using the multigas photoacoustic analyzer in the sample preparation facility.

Tritium and C-14 samples collected from vapor ports placed to monitor SVRs will not require use of a glove bag during sample acquisition. The evaluation supporting the decision on glove bag use while collecting radioactive soil-gas samples from the vapor ports is included in EDF-ER-248, "Estimated Emissions, Air Concentrations, and Worker Exposure to Tritium and C-14 Associated with Sample Collection and Analysis." The EDF-ER-248 includes a radiological safety analysis for sampling soil gas containing C-14 and tritium. The EDF-ER-262, "Operable Unit 7-13/14 Integrated Probing Project Tritiated Soil Gas Sampling System for the Soil Vault Rows," defines the tritiated soil gas sample acquisition system located around the SVRs. The TPR-1771, "Soil Gas Sampling in the Soil Vault Rows," is used to acquire the tritium samples. The TPR-1633, "Soil Gas Sampling for Tritium and C-14 with Gas Washing Bottles," describes the procedure for preparing and collecting C-14 samples. A new procedure that does not involve the use of caustic base material in the field may be developed to replace TPR-1633.

5.2 Electronic Sample Data Acquisition

The system to acquire electronic data from sensors in the Type B probes is described in EDF-ER-240, "OU 7-13/14 Integrated Probing Project Data Acquisition System for Type B Probes Design." This EDF includes descriptions of standard output from tensiometers, moisture sensors, and the geochemical probes. Electronic data will be collected in accordance with TPR-1669, "Type B Probe Data Acquisition System Installation and Maintenance." Electronic data downloaded from the Type B probes will be transferred to the INEEL hydrological data repository for access control and long-term archiving.

5.3 Field Documentation and Custody Requirements

5.3.1 Field Documentation

Additional details of the elements of sample documentation covered in this section are in the QAPjP. The field team leader or designee is responsible for controlling and maintaining all field documents and records and ensuring that all required documents are submitted to the Environmental Restoration field data coordinator within 6 weeks of the project completion.

The identification number and disposition of controlled documents (e.g., logbooks) will be recorded in the Environmental Restoration document control logbook. If any documents are lost, the loss of the document and an explanation of how the loss was rectified will be recorded in the document control logbook. The identification number and disposition of all damaged or destroyed field documents will also be recorded. All voided and completed documents will be maintained in a project file until project completion, at which time all logbooks, chain-of-custody copies, and other relevant records will be submitted to Environmental Restoration document control.

Necessary field documents include the following:

- Chain-of-custody forms
- Sample logbook
- Quality Assurance Project Plan
- This FSP
- Relevant TPRs
- Health and Safety Plan (Miller 2001).

5.3.2 Labels

A waterproof, gummed label identifies all samples. The label will contain sample collection time and date, sample identification number, preservation used (if any), type of analysis, and other pertinent information. MCP-1192, "Chain of Custody and Sample Labeling for ER and D&D&D Projects," establishes the sample container labeling procedure for this project.

5.3.3 Sample Custody

The chain-of-custody record is a form that serves as a written record of sample handling. When a sample changes custody, the person(s) relinquishing and receiving the sample will sign a chain-of-custody record. Each change of possession will be documented, thus a written record that tracks sample handling will be established. MCP-1192 establishes the custody procedure for this project.

5.3.4 Logbooks

Information pertaining to sampling activities will be entered in the sample logbook. Entries will be dated and signed by the individual making the entry. All logbooks will have a quality control check for accuracy and completeness. MCP-1194, "Logbook Practices for ER and D&D&D Projects," establishes the logbook use and administration procedure for this project.

5.4 Quality Assurance

Analytical procedures that support this project will generate both screening and definitive data, as defined by the QAPjP. Screening data will be supported by collection of a limited number of QA samples analyzed under standard laboratory conditions and resulting in definitive confirmation or, more appropriately, a data set to support an evaluation of the effectiveness of the screening data.

5.4.1 Quality Assurance for Water Samples

Water samples described in Section 3 will be analyzed in established laboratories under a task order SOW issued by the INEEL SMO, and data from the analyses will be considered definitive. Standard laboratory QA will be followed, with minor exceptions. Water sample volume is expected to be extremely limited, so some laboratory QA sample analyses requiring collection of extra sample volume (e.g., matrix spikes and matrix spike duplicates) may not be performed because the limited sample volume will typically be used for the analytical suites described in Section 3.

Table 1-5 of the QAPjP describes generally recommended field QA sampling. The table includes the following items:

- Duplicates
- Field blanks
- Trip blanks
- Equipment rinsate blanks.

For this project, duplicate samples will be collected at the frequency prescribed in the QAPjP, if sufficient sample material exists. Table 1-5 of the QAPjP recommends collecting the duplicate samples at a frequency of 5%. It is anticipated that the lysimeter from which the field duplicate can be collected can be determined only after the sample is collected and enough water is determined to be present to meet the analytical requirements for both the regular and the collocated duplicate sample. This will be a

split sample because it will be subdivided or split from the original sample following collection. Since the analytical laboratory may be splitting part of the sample, this duplicate may not be submitted “blind” to the laboratory.

Field blanks and equipment rinsates will not be collected as part of this investigation. Field blanks are generally used to evaluate cross contamination during sample collection activities. Because a dedicated and essentially closed system is used to collect the water samples, the chance of significant cross contamination is remote. In addition, equipment rinsates are not required because dedicated and disposable sampling equipment is being used and decontamination of the internal portions of sampling equipment is not anticipated.

Trip blanks are not anticipated to be collected during this investigation. Therefore, detections of VOCs will not be attributable to cross contamination during storage and transport. Not collecting trip blanks is expected to save a considerable amount of money. The savings is a result of the large numbers of trip blanks that would be required if shipped with every cooler containing samples for volatile-organic analysis, which is traditional with typical environmental investigations.

5.4.2 Quality Assurance for Volatile Organic Compound Soil-Gas Samples

Field QA associated with the analyses of VOC samples collected from the vapor ports and analyzed with a multigas photoacoustic analyzer will consist of analyses of the following sample types:

- Laboratory control samples (analyzed during use of the multigas photoacoustic analyzer)
- Duplicates.

Laboratory control samples will be analyzed with regular samples during field operations using the multigas photoacoustic analyzers. Laboratory control samples will be used as a measure of accuracy of the method. Typical laboratory control samples may include the suite established by the INEEL OCVZ program. These include calibration gases consisting of a mixture of each of the five target VOCs at concentrations of 1 ppm, 100 ppm, and a laboratory control sample containing CCL₄ at 1,000 ppm, with nitrogen as the balance for the suite of laboratory control samples. If the results of the calibration differ by more than 20% from the calibration gas standards, corrective action must be taken, which may include sending the analyzer back to the factory for recalibration. If soil-gas sampling has already started, sample collection and analysis may continue, however, the calibration problems and limitations of the data set will be noted.

Field duplicates will be collected, at an approximate 5% frequency of the regular samples, from vapor ports being sampled for VOCs. These will be collocated samples (i.e., a sample collected immediately following the collection of the regular sample from the same vapor port). Field duplicates collected in this manner are used to estimate field precision, which is a measure of variability assumed to be caused by field conditions.

In addition to the field duplicate described above, a second type of duplicate sample will be collected. Duplicate samples will be collected for standard laboratory GC/MS analysis, as an accuracy check on the multigas photoacoustic analyzer chosen for analysis of the regular VOC soil-gas samples. These samples are expected to be collected, using a summa canister, in accordance with TPR-1674 and analyzed by the environmental chemistry laboratory located at Central Facilities Area (CFA)-625 or at another approved facility. The analytical method currently used for VOC analysis at CFA-625 is Analytical Laboratories Department Procedure ACMM-9930, “GC/MS MFC for VOCs in Gas” (Crowder 2000). These duplicates will be used to verify the accuracy of the field method and will be

collected at the rate of approximately 5% of the regular samples. Following several rounds of sampling, the frequency of this QA check may be reevaluated and the frequency altered, as necessary.

5.5 Waste Management

Small amounts of investigation-derived waste will be generated by the sample-handling activities that support this project. The waste resulting from the activities during the OU 7-13/14 integrated probing project investigation could be classified into the following categories: (1) industrial (both conditional and nonconditional), (2) low-level, and (3) mixed low-level. These waste categories will be managed and disposed of in accordance with provisions in the final ROD for OU 7-13/14, the *INEEL Waste Acceptance Criteria (WAC)* (DOE-ID 2002b), MCP-3475, "Temporary Storage of CERCLA-Generated Waste at the INEEL," and applicable state and federal regulations. If unaltered samples are returned from the analytical laboratory or are archived for any reason, the samples will be handled in accordance with MCP-3480, "Environmental Instructions for Facilities, Processes, Materials and Equipment." Waste management support will be provided by the Waste Generator Services (WGS) organization in accordance with MCP-3480.

All generated waste will be characterized as required by companywide management control procedures, DOE Orders 435.1, "Radioactive Waste Management," and 5400.5, "Radiation Protection of the Public and the Environment," and Resource Conservation and Recovery Act (RCRA) regulations found in 40 CFR 262.11. Based on the characterization, hazardous waste determinations will be performed and documented to assign the appropriate U.S. Environmental Protection Agency waste codes. A hazardous waste determination uses one of two approaches (or a combination of both) to determine whether the waste is RCRA hazardous waste. Process knowledge may be used if there is sufficient information to characterize the waste. Process knowledge may include direct knowledge of the source of the contamination or existing analytical data. Representative samples of the waste stream may also be analyzed. Process knowledge may influence the amount of sampling and analysis required to perform this characterization.

In addition to characterization of waste under RCRA, consideration must be given to the potential that the sampling waste could contain polychlorinated biphenyls (PCBs) above established regulatory thresholds (50 ppm). Polychlorinated biphenyls exist in some RFP waste (i.e., the source of the PCBs). However, the relatively low solubility characteristics of PCBs, and other controls, strongly suggest that residual waste generated from these sampling activities are unlikely to contain PCBs above established regulatory thresholds. All but the lightest PCBs have aqueous solubilities considerably below 1 ppm. (PCBs are generally considered very insoluble in water.) In addition, the lysimeters used to collect water samples (water being the only potential "carrier" for PCB contamination during this project) have inlet ports (e.g., sintered porous stainless steel) that are "water wet." Therefore, if the probes were completed in areas containing PCB oils, the oils could not pass through the porous steel without displacing the water contained in the porous stainless steel. Regardless of any issue with PCBs, the vacuum required to displace this water would severely compromise the lysimeter (essentially make it inoperable for good) therefore, administrative controls are in place (e.g., TPR-1674) to eliminate this possibility. Finally, PCB solubility is known to increase when mixed with some organic solvents. Though this potential increase in solubility is unlikely to allow waste generated from this project to exceed regulatory thresholds, limited testing of sampling residuals by the analytical laboratory for PCBs is prudent and will be used to support a final PCB-related waste determination.

5.5.1 Waste Minimization and Segregation

Project waste will be minimized through design and planning to ensure efficient operations that do not generate unnecessary waste. Waste reduction philosophies and techniques will be emphasized as part of the prejob briefing, and personnel will be encouraged to continuously attempt to improve methods for minimizing waste generation. Practices to be instituted to support waste minimization include, but are not limited to, the following:

- Restricting material, especially hazardous material entering radiological buffer areas, to that needed for work
- Substituting recyclable items for disposable items
- Reusing items, when practical
- Segregating contaminated and uncontaminated waste
- Segregating reusable items (e.g., personal protective equipment [PPE] and tools).

5.5.2 Packaging

All waste material packaging will comply with the INEEL WAC, U.S. Department of Transportation (DOT) regulations (49 CFR 171, 173, 177, and 178), and RCRA regulations found in 40 CFR 264, Subpart I. Storage containers used to store hazardous waste must be in good condition and compatible with the waste being stored. It is also important that containers selected for storage of all waste (e.g., hazardous, radioactive, or industrial) are compatible with final disposition plans for the waste. This will alleviate the need for repackaging the waste prior to shipment to a treatment or disposal facility. The following general container categories are anticipated for storage of various OU 7-13/14 Type B probing project investigation-derived waste and contaminated environmental media, if necessary:

- 55-gal (208-L) drums
- 20 × 8 × 8-ft (9 × 29 × 29-m), or similarly dimensioned, steel-reinforced cargo containers.

The WGS and packaging and transportation personnel will be consulted to verify the specific types of containers to be used for the anticipated waste. Only new or like-new containers will be used (except for cargo containers). Radioactive material must be packaged to adequately protect the material from weather, and the outside packaging must be free of removable radioactive contamination. It is anticipated that most of the contained waste and environmental media generated during the sampling investigations will be stored outside and, therefore, will need to be protected from the elements. The exception to this is waste stored in cargo containers.

5.5.3 Labeling

All waste containers will be labeled appropriately. Conditional waste will be labeled as such. All CERCLA investigation-derived waste will be labeled with a CERCLA waste label that includes an accumulation start date, waste description, applicable waste codes, and the generator's name. Each container will have a barcode label generated from the INEEL Integrated Waste Tracking System (IWTS) database. All container labels will be placed where they are clearly visible during storage and shipment. Drums will be labeled on top and on the side. If cargo containers are used, they will be labeled

on two opposing sides. Radiation labels will be completed and placed on each container by a radiological control technician, as required by the INEEL *Radiological Control Manual*. During shipment, other information must be included on containers, such as applicable DOT labels, manifest number, gross weight, and complete name and address of shipper.

5.5.4 Storage, Inspections, and Record Keeping

Most containers of CERCLA investigation-derived waste generated from this investigation will be stored in a CERCLA storage area (CSA) located inside the SDA (e.g., CSA No. RWMC-CC027-SDA-A). Waste entering the CSA must comply with this FSP. The CSA complies with all applicable state and federal requirements regarding storage of hazardous and radioactive waste, including having a RCRA contingency plan, emergency communication system and equipment, alarms, and aisle space. When containers are brought into the CSA, the storage area operator will inventory the containers. Information to be recorded will include the IWTS barcode assigned to the container, type of container, type of waste inside the container (including potential waste codes), and the volume of waste inside the container. When each container is logged in, an evaluation will ensure incompatible waste will be segregated. Only personnel with the appropriate and required training will be allowed to receive waste into the CSA.

The CSA will be inspected weekly for leaks, spills, appropriate aisle space for emergency response, appropriate emergency response equipment, appropriate mitigation of any spills or noncompliance, compatibility between waste and containers, segregation requirements, appropriate labels, appropriate signs posted for compliance with applicable radiological requirements, and other applicable requirements and good practices. The weekly inspection will be documented in accordance with the CSA waste management plan. Only personnel with the appropriate and required training will be allowed to perform weekly inspections of the CSA.

All information generated from the storage and inspection of waste in the CSA is considered a quality record and must be kept on file indefinitely. Other quality records to be kept include material and container profiles contained in the INEEL IWTS electronic database. This database contains quality records of (1) sampling and analytical data for waste streams, (2) the hazardous waste determinations for each waste stream, (3) the types, quantities, and content description of containers associated with each waste stream, (4) records of all waste movement (e.g., shipment to an offsite or onsite approved disposal facility), (5) appropriate land disposal restriction notification and certification, and (6) documentation reflecting compliance with debris treatment performance standards.

5.5.5 Transportation

All CERCLA investigation-derived waste generated during the OU 7-13/14 Type B sampling investigations and moved outside of the RWMC will be transported to storage areas or approved offsite or onsite treatment and disposal facilities, in accordance with requirements identified in the INEEL WAC and applicable DOT and RCRA regulations. The WGS and packaging and transport personnel will be responsible for shipping all CERCLA investigation-derived waste. Personnel having the proper documentation may transport industrial waste to the INEEL landfill complex.

5.5.6 Waste Treatment and Disposition

Waste generated during the OU 7-13/14 Type B sampling investigation must be managed and disposed of in accordance with all applicable project documents and state and federal regulations. Disposal options for the various waste classifications are discussed below. Prior to waste disposal, the

waste streams must comply with the waste acceptance criteria of the intended receiving facility and approval for disposal must be obtained.

In limited cases, some hazardous debris treatment may be conducted on site to support waste disposition and waste minimization goals. Material that would normally be considered for decontamination (e.g., a plastic glove bag) may be candidate material for debris treatment under 40 CFR 268.45 of RCRA. In the context of implementing this plan, these hazardous debris treatment activities would be limited to washing and spraying nonporous materials (e.g., plastics). Hazardous debris (as provided in 40 CFR 268.45[c]) that has been treated using one of the specified extraction or destruction technologies, and does not exhibit a characteristic of hazardous waste after treatment (as identified in Subpart C, Part 261), is not hazardous waste and need not be managed in a Subtitle-C facility. However, any residues resulting from the treatment of hazardous debris (e.g., rags) will be managed in accordance with the relevant requirements of 40 CFR 268.45(d). These activities will be coordinated with WGS and project environmental affairs personnel.

5.5.7 Conditional and Nonconditional Industrial Waste

Conditional industrial waste would include clean PPE, RCRA-empty containers, or other items determined to be nonhazardous and nonradioactive. Conditional waste has been through the hazardous waste determination process and is typically disposed of in the INEEL landfill complex. Nonconditional industrial waste usually includes administrative paper waste and lunch-type waste, and is disposed of in green cold-waste dumpsters located around the INEEL. Waste from these dumpsters is disposed of at the INEEL landfill complex.

5.5.8 Mixed Hazardous and Radioactive Waste (Mixed Waste)

As seen in Table 11, some waste potentially generated in association with the OU 7-13/14 Type B integrated probing project-sampling activities may be classified as mixed waste, pending hazardous waste determination. Types of waste that could be classified as mixed waste include PPE, contamination control supplies, unused sample material, analytical residue, contaminated equipment, and decontamination fluid. Generally, waste coming into direct contact with liquid sample material collected from lysimeters would be candidate material for this characterization.

5.5.9 Radioactive Waste

Some waste, including that anticipated to be generated during the OU 7-13/14 Type B integrated probing project-sampling activities, will be classified as radioactive only (see Table 11). Radioactive waste has been identified as sample containers that held mixed waste and are now RCRA-empty. Disposal options include the RWMC or the INEEL CERCLA Disposal Facility.

If any of the projected mixed waste streams can be determined to be no longer hazardous, the classification could change to radioactive only. All waste classifications will be documented by completed hazardous waste determinations. As previously stated, disposal options for radioactive waste include the RWMC.

Table 11. Projected waste generation and waste management considerations.

Potential Waste Stream	Base Composition	Probable Volume	Expected Characterization	Notes
Glove bags and internal piping and equipment	Plastics, high-efficiency particulate air (HEPA) filters, metal tubing, valves, and connectors	< 2 m ³ /year	Low-level waste (LLW) or mixed waste	—
Personal protective equipment (PPE) and wipes	Tyvek, latex, Kimwipes	< 2 m ³ /year	LLW or mixed waste	—
Liquid sample collection jars, laboratory pipettes	Fluorinated high-density polyethylene (HDPE), Teflon, Tefzel tubing, metal and plastic valves, glassware	< 2 m ³ /year	LLW or mixed waste	Use of empty container rule to exit RCRA
Original supply and sample container boxes, administrative waste paper	Paper, cardboard	< 1 m ³ /year	Nonconditional industrial waste	Disposition in green cold-waste dumpsters for INEEL landfill complex disposal
Used but “clean” PPE, nonradioactive Resource Conservation and Recovery Act (RCRA) -empty containers (e.g., Tedlar bags used in volatile organic compound [VOC] sampling)	PPE, Tedlar bags, glass and plastic bottles	< 1 m ³ /year	Conditional industrial waste	INEEL landfill complex disposal expected Tedlar bags expected to be conditional following radiological swipe of the inside of the “wasted” bags Bags protected by HEPA, residual VOCs purged following analysis
Tygon tubing, potentially C-14-gas contaminated	Tygon or plastic tubing, metal valves, fittings	< 0.1 m ³ /year (15 ft/day)	LLW or conditional industrial waste	Radiological control technician evaluation required.

6. REFERENCES

Note: Company-controlled documents referenced in this section are revised routinely. The current versions of these documents apply to field use. Draft technical procedures are provided below for information only and do not become requirements until they are finalized.

- 42 USC § 9601 et seq., December 11, 1980, *United States Code*, “Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA/Superfund).”
- 40 CFR 141.15, *Code of Federal Regulations*, Title 40, “Protection of the Environment,” Subchapter D, “Water Programs,” Part 141, “National Primary Drinking Water Regulations,” Subpart .15, “Maximum Contaminant Levels for Radium-226, Radium-228, and Gross Alpha Particle Radioactivity in Community Water Systems.”
- 40 CFR 141.16, *Code of Federal Regulations*, Title 40, “Protection of the Environment,” Subchapter D, “Water Programs,” Part 141, “National Primary Drinking Water Regulations,” Subpart .16, “Maximum Contaminant Levels for Beta Particle and Photon Radioactivity from Man-Made Radionuclides in Community Water Systems.”
- 40 CFR 141.51, *Code of Federal Regulations*, Title 40, “Protection of the Environment,” Subchapter D, “Water Programs,” Part 141, “National Primary Drinking Water Regulations,” Subpart .51, “Maximum Contaminant Levels for Inorganic Contaminants.”
- 40 CFR 141.61, *Code of Federal Regulations*, Title 40, “Protection of the Environment,” Subchapter D, “Water Programs,” Part 141, “National Primary Drinking Water Regulations,” Subpart .61, “Maximum Contaminant Levels for Organic Contaminants.”
- 40 CFR 262.11, *Code of Federal Regulations*, Title 40, “Protection of Environment,” Part 262, “Standards Applicable to Generators of Hazardous Waste,” Section 11, “Hazardous Waste Determination.”
- 40 CFR 264 Subpart I, *Code of Federal Regulations*, Title 40, “Protection of Environment,” Part 264, “Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” Subpart I, “Use and Management of Containers.”
- 40 CFR 268.45, *Code of Federal Regulations*, Title 40, “Protection of Environment,” Part 268, “Land Disposal Restrictions,” Section 268.45, “Treatment Standards for Hazardous Debris.”
- 49 CFR 171, *Code of Federal Regulations*, Title 49, “Transportation,” Part 171, “General Information, Regulations, and Definitions.”
- 49 CFR 173, *Code of Federal Regulations*, Title 49, “Transportation,” Part 173, “Shippers – General Requirements for Shipments and Packagings.”
- 49 CFR 177, *Code of Federal Regulations*, Title 49, “Transportation,” Part 177, “Carriage by Public Highway.”
- 49 CFR 178, *Code of Federal Regulations*, Title 49, “Transportation,” Part 178, “Specifications for Packagings.”
- U.S. Department of Energy Order 435.1, “Radioactive Waste Management,” July 9, 1999, U.S. Department of Energy.

U.S. Department of Energy Order 5400.5, "Radiation Protection of the Public and the Environment," January 7, 1993, U.S. Department of Energy.

Becker, B. H., K. J. Holdren, C. B. Potelunas, and T. R. Sherwood, 1999, *Operable Unit 7-13/14 Plan for the Installation and Logging of Probeholes in Pits 4 and 10 of the Subsurface Disposal Area*, INEL-EXT-98-00856, Idaho National Engineering and Environmental Laboratory, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho.

Becker, B. H., J. D. Burgess, K. J. Holdren, D. K. Jorgensen, S. O. Magnuson, and A. J. Sondrup, 1998, *Interim Risk Assessment and Contaminant Screening for the Waste Area Group 7 Remedial Investigation*, DOE/ID-10569, Idaho National Engineering and Environmental Laboratory, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho.

Bishop, C. W., 1996, *Soil Moisture Monitoring Results at the Radioactive Waste Management Complex of the Idaho National Engineering Laboratory, FY-96, FY-95, and FY-94*, INEL-96/297, LMITCO Internal Report, Idaho National Engineering and Environmental Laboratory, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho.

Case, Marilyn J., Arthur S. Rood, James M. McCarthy, Swen O. Magnuson, Bruce H. Becker, and Thomas K. Honeycutt, 2000, *Technical Revision of the Radioactive Waste Management Complex Low-Level Waste Radiological Performance Assessment for Calendar Year 2000*, INEEL/EXT-2000-01089, Idaho National Engineering and Environmental Laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho.

Crowder, Catherine A., April 12, 2000, "GC/MS MFC for VOCs in Gas," ACMM-9930, Rev. 4, *Analytical Chemistry Methods Manual*, Idaho National Engineering and Environmental Laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho.

Day, R. E., J. R. Dick, K. J. Holdren, R. W. Ovink, and M. E. Todd, 2001, *Waste Area Group 7 Operable Unit 7-13/14 Data Quality Objectives Report*, INEEL/EXT-2000-01418, Rev. 0, CH2M Hill for the Idaho National Engineering and Environmental Laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho.

DOE-ID, 2002a, *Quality Assurance Project Plan for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, 10, and Inactive Sites*, DOE/ID-10587, Rev. 7, September 2002.

DOE-ID, 2002b, *INEEL Waste Acceptance Criteria*, DOE/ID-01-10381, Rev. 14, U.S. Department of Energy Idaho Operations Office, Idaho Falls, Idaho.

DOE-ID, 1998, *Addendum to the Work Plan for the Operable Unit 7-13/14 Waste Area Group 7 Comprehensive Remedial Investigation/Feasibility Study*, DOE/ID-10622, August 1998.

DOE-ID, 1991, *Federal Facility Agreement and Consent Order and Action Plan*, U.S. Department of Energy, Idaho Field Office; U.S. Environmental Protection Agency, Region 10; Idaho Department of Health and Welfare, December 4, 1991.

EDF-ER-234, 2001, "OU 7-13/14 Integrated Probing Project Soil Moisture Instrumented Probe," Rev. 1, Environmental Restoration, August 2, 2001.

EDF-ER-235, 2001, "OU 7-13/14 Integrated Probing Project Vapor Port Instrumented Probe," Rev. 0, Environmental Restoration, August 1, 2001.

- EDF-ER-236, 2001, "OU 7-13/14 Integrated Probing Project Type B Probes Lysimeter Probe Design," Environmental Restoration, May 11, 2001.
- EDF-ER-237, 2001, "OU 7-13/14 Integrated Probing Project Type B Probes Visual Probe Design," Rev. 0, Environmental Restoration, May 25, 2001.
- EDF-ER-238, 2001, "OU 7-13/14 Integrated Probing Project OU 7-13/14 Tensiometer Probe Design," Rev. 0, Environmental Restoration, March 27, 2001.
- EDF-ER-240, "OU 7-13/14 Integrated Probing Project Data Acquisition System for Type B Probes Design," Rev. 1, Environmental Restoration, December 19, 2002.
- EDF-ER-248, 2001, "Estimated Emissions, Air Concentrations, and Worker Exposure to Tritium and Carbon-14 Associated with Sample Collection and Analysis," Rev. 0, Environmental Restoration, May 31, 2001.
- EDF-ER-262, 2002, "Operable Unit (OU) 7-13/14 Integrated Probing Project Tritiated Soil Gas Sampling System for the Soil Vault Rows," Rev. 0, Environmental Restoration, January 28, 2002.
- EPA, 1998, Environmental Technology Verification Report, *Photoacoustic Infrared Monitor*, INNOVA AirTech Instruments Type 1312 Multigas Monitor, EPA/600/R-98/143, U.S. Environmental Protection Agency.
- EPA, 1988, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, EPA-520/1-88-020, Federal Guidance Report, FGR-11, U.S. Environmental Protection Agency.
- ER-SOW-394, 2002, "Idaho National Engineering and Environmental Laboratory Sample and Analysis Management Statement of Work for Analytical Services," Rev. 1, December 2002.
- INEEL, 2001, *Technical and Functional Requirements for the Operable Unit 7-13/14 Integrated Probing Project Type B Probes*, INEEL/EXT-2000-01429, TFR-105, Rev 0, Idaho National Engineering and Environmental Laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho.
- INEEL, 2000, *Operable Unit 7-13/14 Plan for the Installation, Logging, and Monitoring of Probeholes in the Subsurface Disposal Area*, INEEL/EXT-98-00856, Rev 1, Idaho National Engineering and Environmental Laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho.
- LMITCO, 1999, *Progress Report: Tritium and Carbon-14 Sampling at the Radioactive Waste Management Complex*, INEEL/EXT-98-00669, Idaho National Engineering and Environmental Laboratory, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho.

- Logan, J. A., Interdepartmental Communication to T. L. Clements, Jr., G. E. Ellis, and W. W. Gay, September 9, 1999, "Assessment of Neutron-Activation Products in Low-Level Waste Discharged from Nuclear Reactors at the Test Reactor Area and Sent to the Radioactive Waste Management Complex for Disposal," JAL-04-99, Idaho National Engineering and Environmental Laboratory, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho.
- MCP-227, 1999, "Sampling and Analysis Process for CERCLA and D&D Activities," Rev. 7, Closure Management, September 3, 1999.
- MCP-1192, 2003, "Chain of Custody and Sample Labeling for ER and D&D&D Projects," Rev. 0, February 27, 2003.
- MCP-1194, 2003, "Logbook Practices for ER and D&D&D Projects," Rev. 1, May 14, 2003.
- MCP-3475, 1999, "Temporary Storage of CERCLA-Generated Waste at the INEEL," Rev. 1, Closure Management, September 3, 1999.
- MCP-3480, 2001, "Environmental Instructions for Facilities, Processes, Materials and Equipment," Rev. 6, Environmental Protection and Compliance, June 1, 2001.
- Mandler, J. W., and J. R. Giles, December 2000, Letter Report, *Operable Unit 7-13/14 Depleted Uranium and 741 Study Area Probehole Recommendations*, Idaho National Engineering and Environmental Laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho.
- Shakofsky, S. M., 1995, *Changes in Soil Hydraulic Properties Caused by Construction of a Simulated Waste Trench at the Idaho National Engineering Laboratory Idaho*, U.S. Geological Survey Water Resources Investigation Report 95-4058, DOE/ID-22121, U.S. Department of Energy Idaho Operations Office, Idaho Falls, Idaho.
- Sifuentes, S., and S. J. Moody, 2001, *OU 7-13/14 Integrated Probing Project Sample Acquisition and Glove Bag Design*, Engineering Design File EDF-ER-239, Rev. 1, Idaho National Engineering and Environmental Laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho.
- Sullivan, T. M., May 1993, *Disposal Unit Source Term (DUST) Data Input Guide*, NUREG/CR6041, BNL-NUREG-52375, Brookhaven National Laboratory, Brookhaven, New York.
- TPR-1633, 2001, "Soil Gas Sampling for Tritium and C-14 with Gas Washing Bottles," Rev. 1, *RWMC Technical Procedures Manual*, April 26, 2001.
- TPR-1669, 2003, "Type B Probe Data Acquisition System Installation and Maintenance," Rev. 2, *RWMC Technical Procedures Manual*, May 22, 2003.
- TPR-1671, 2002, "Visual Probe Logging Procedure," Rev. 1, *RWMC Technical Procedures Manual*, September 24, 2002.
- TPR-1672, 2003, "Type B Probe Installation," Rev. 6, *RWMC Technical Procedures Manual*, May 29, 2003.
- TPR-1673, 2003, "Type B Visual Probe Installation," Rev. 6, *RWMC Technical Procedures Manual*, June 3, 2002.

TPR-1674, 2003, "Glove Bag Supported Sample Acquisition from Type B Probes in the Subsurface Disposal Area," Rev. 8, *RWMC Technical Procedures Manual*, May 6, 2003.

TPR-1763, 2002, "Type B Tensiometer Operations and Maintenance," Rev. 2, *RWMC Technical Procedures Manual*, April 2, 2002.

TPR-1771, 2002, "Soil Gas Sampling in the Soil Vault Rows," Rev. 1, Environmental Restoration, September 24, 2002.

Appendix A

Information Used to Determine Vertical Placement of Type B Probes Around Existing Logged Type A Probes

Appendix A

Information Used to Determine Vertical Placement of Type B Probes Around Existing Logged Type A Probes

The following report formed the basis to determine the vertical placement of Type B probes around the existing logged Type A probes.

WASTE BOUNDARIES AND DEPTH TO BASALT

Interpreted from Downhole Logging Data

Nicholas E. Josten and Hopi Salomon

Principle

The waste boundary interpretation was based on the principle that the waste zone contains less soil and greater void space than the overlying cap and underburden, although pockets of pure soil may certainly be scattered throughout the interior of the waste zone. On this principle, logging data were used to identify reductions in the amount of common soil components (especially silicon and potassium), as well as changes in water content and void space, as indicated by moisture log data. These reductions were interpreted to reflect the transition from pure soil to soil-waste mixtures. The shallowest transition was marked as the upper waste boundary and the deepest transition was marked as the lower waste boundary.

Method

Silicon, potassium, and moisture logs were the primary data sets used for interpreting waste boundaries, but thorium, calcium, hydrogen, and iron were also considered. Table A-1 shows the logging methods used for the various soil indicators. For each well grouping (i.e., 741, 743, and depleted uranium study areas), logging data were compiled into cross sections to accommodate recognition of trends between probes. A trend line representing the interpreted position of the soil-waste transition was constructed across each cross section. Depths were then read from the cross sections and compiled into Table A-2. Finally, interpreted boundaries were compared against contamination indicators (e.g., gross gamma, gross neutrons, and chlorine) to assure consistency and to recognize noise sources.

Table A-1. Logging methods used for waste boundary interpretation.

Logging method	Soil indicators
Passive spectral gamma-ray	K-40, Th-232
Activated spectral gamma-ray	Silicon, calcium, hydrogen, iron
Neutron-neutron	Hydrogen, void space

Depth to basalt was assumed to correspond with the drilling total depth, which was measured by the drilling crew after probe installation. In cases where the total depth was not measured, depth to basalt

was estimated based on the maximum logging depth, which averaged 0.6 ft (18 cm) above the total depth.

In some cases, no lower waste boundary was recognized. In these cases the boundary was assumed to lay below the maximum logged depth and Table A-2 lists maximum logged depth as the minimum depth of this boundary.

Table A-2. Waste boundary depths and depth to basalt, based on logging data interpretation, and suggested vertical completion depths (all measurements in feet) below ground surface.

Type A Well ID	Top of Waste	Bottom of Waste	Max Logged Depth	Drilling Total Depth	Depth to Basalt	Waste Zone Thickness	Tensiometer			Soil Moisture Probe			Lysimeter			Vapor Port			Oxidation- Reduction Potential	
							T1	T2	T3	M1	M2	M3	L1	L2		VP1	VP2	VP3	/pH	Visual
DU-01	4.7	10.2	13.7	14.3	14.3	5.5	10.2	6.5	4.7	10.2	7.5	4.7	10.2			9.5	7.5	4.7	10.2	14.3
DU-02	5.8	9.8	12	14.8	14.8	4	9.8	7.1	5.8	9.8	7.8	5.8	9.8			9.1	7.8	5.8	9.8	14.8
DU-03	5.3	9.6	13.8	14.5	14.5	4.3	9.6	6.7	5.3	9.6	7.5	5.3	9.6			8.9	7.5	5.3	9.6	14.5
DU-04	No waste	No waste	13.4	14	14															
DU-05	5.9	9.1	17.8	18.3	18.3	3.2	9.1	7.0	5.9	9.1	7.5	5.9	9.1			8.4	7.5	5.9	9.1	18.3
DU-06	5.2	9	17.7	18.5	18.5	3.8	9	6.5	5.2	9	7.1	5.2	9			8.3	7.1	5.2	9	18.5
DU-07	5.6	9	13.8	14.5	14.5	3.4	9	6.7	5.6	9	7.3	5.6	9			8.3	7.3	5.6	9	14.5
DU-08	5.2	16.3	17.7	18.4	18.4	11.1	16.3	8.9	5.2	16.3	10.8	5.2	16.3	14.5		15.6	10.8	5.2	16.3	18.4
DU-09	5.3	11.2	12.9	13.2	13.2	5.9	11.2	7.3	5.3	11.2	8.3	5.3	11.2			10.5	8.3	5.3	11.2	13.2
DU-10	4.6	10	16.8	17.3	17.3	5.4	10	6.4	4.6	10	7.3	4.6	10	7.5		9.3	7.3	4.6	10	17.3
DU-11	4.9	15.6	17.5	18.1	18.1	10.7	15.6	8.5	4.9	15.6	10.3	4.9	15.6			14.9	10.3	4.9	15.6	18.1
DU-12	6.4	13.2	17.8	18.3	18.3	6.8	13.2	8.7	6.4	13.2	9.8	6.4	13.2			12.5	9.8	6.4	13.2	18.3
DU-13	6.3	15.9	17.6	18.1	18.1	9.6	15.9	9.5	6.3	15.9	11.1	6.3	15.9			15.2	11.1	6.3	15.9	18.1
DU-14	5.5	>16.7	16.7	17.2	17.2	11.2	16.7	9.2	5.5	16.7	11.1	5.5	16.7	8		16	11.1	5.5	16.7	17.2
DU-15	5.8	>16.6	16.6	17.1	17.1	10.8	16.6	9.4	5.8	16.6	11.2	5.8	16.6			15.9	11.2	5.8	16.6	17.1
DU-16	5.4	>15.9	15.9	20.2	20.2	10.5	15.9	8.9	5.4	15.9	10.7	5.4	15.9	13.5		15.2	10.7	5.4	15.9	20.2
DU-17	6	18.4	19.7	NA	20.3	12.4	18.4	10.1	6	18.4	12.2	6	18.4			17.7	12.2	6	18.4	20.3
741-02	7.9	14.2	17.5	18.1	18.1	6.3	14.2	10.0	7.9	14.2	11.1	7.9	14.2	11.5		13.5	11.1	7.9	14.2	18.1
741-03	7.3	16	18.7	20.7	20.7	8.7	16	10.2	7.3	16	11.7	7.3	16			15.3	11.7	7.3	16	20.7
741-04	7.4	18.2	23.7	24.3	24.3	10.8	18.2	11.0	7.4	18.2	12.8	7.4	18.2			17.5	12.8	7.4	18.2	24.3
741-06	6.7	>17.4	17.4	18	18	10.7	17.4	10.3	6.7	17.4	12.1	6.7	17.4			16.7	12.1	6.7	17.4	18
741-08	5.8	15.7	21.3	21.8	21.8	9.9	15.7	9.1	5.8	15.7	10.8	5.8	15.7	8		15	10.8	5.8	15.7	21.8

Table A-2 (continued)

Suggested Placement bgs by Probe Type																			
Type A Well ID	Top of Waste	Bottom of Waste	Max Logged Depth	Drilling Total Depth	Depth to Basalt	Waste Zone Thickness	Tensiometer			Soil Moisture Probe			Lysimeter		Vapor Port			Oxidation-Reduction Potential	
							T1	T2	T3	M1	M2	M3	L1	L2	VP1	VP2	VP3	pH	G
741-09	9.7	>13.8	13.8	14.3	14.3	4.1	13.8	11.1	9.7	9.7	13.8	11.8	9.7	13.8	13.1	11.8	9.7	13.8	14.3
743-01	7	11	15.5	17.2	17.2	4	11	8.3	7	7	11	9.0	7	11	10.3	9.0	7	11	17.2
743-02	6.5	13.5	19.4	20.7	17.7	7	13.5	8.8	6.5	6.5	13.5	10.0	6.5	13.5	12.8	10.0	6.5	13.5	20.7
743-03	7	13	19.1	19.5	19.5	6	13	9.0	7	7	13	10.0	7	13	12.3	10.0	7	13	19.5
743-04	7	15	24.5	25.5	15.5	8	15	9.7	7	7	15	11.0	7	15	14.3	11.0	7	15	25.5
743-05	8	23.5	26.3	27	27	15.5	23.5	13.2	8	8	23.5	15.8	8	23.5	22.8	15.8	8	23.5	27
743-06	7	>25.8	25.8	26.2	26.2	18.8	25.8	13.3	7	7	25.8	16.4	7	25.8	25.1	16.4	7	25.8	26.2
743-07	7	>24.7	24.7	25.3	25.3	17.7	24.7	12.9	7	7	24.7	15.9	7	24.7	24	15.9	7	24.7	25.3
743-08	10.5	>24.9	24.9	25.3	25.3	14.4	24.9	15.3	10.5	10.5	24.9	17.7	10.5	24.9	24.2	17.7	10.5	24.9	25.3
743-09	8	>23.8	23.8	24.3	24.3	15.8	23.8	13.3	8	8	23.8	15.9	8	23.8	23.1	15.9	8	23.8	24.3
743-10	9	>25.4	25.4	25.8	25.8	16.4	25.4	14.5	9	9	25.4	17.2	9	25.4	24.7	17.2	9	25.4	25.8
743-11	11	>24.9	24.9	25.5	25.5	13.9	24.9	15.6	11	11	24.9	18.0	11	24.9	24.2	18.0	11	24.9	25.5
743-12	11	>24.4	24.4	25.6	25.6	3.4	24.4	15.5	11	11	24.4	17.7	11	24.4	23.7	17.7	11	24.4	25
743-13	10	>25	25	25.6	25.6	15	25	15.0	10	10	25	17.5	10	25	24.3	17.5	10	25	25.6
743-14	11	>22.4	22.4	23	23	11.4	22.4	14.8	11	11	22.4	16.7	11	22.4	21.7	16.7	11	22.4	23
743-15	11	>21.4	21.4	21.9	21.9	10.4	21.4	14.5	11	11	21.4	16.2	11	21.4	20.7	16.2	11	21.4	21.9
743-16	9	>14.9	14.9	16.2	16.2	5.9	14.9	11.0	9	9	14.9	12.0	9	14.9	14.2	12.0		14.9	16.2
743-17	9	17	19.2	20.7	20.7	8	17	11.7	9	9	17	13.0	9	17	16.3	13.0		17	20.7
743-18	10	16	20.5	21	21	6	16	12.0	10	10	16	13.0	10	16	15.3	13.0	10	16	21
743-20	9.5	14.5	15.7	16.3	16.3	5	14.5	11.2	9.5	9.5	14.5	12.0	9.5	14.5	13.8	12.0	9.5	14.5	16.3
743-21	12.5	>12.7	12.7	14.8	14.8	0.2	12.7	12.6	12.5	12.5	12.7	12.6	12.5	12.7	12	12.6	12.5	12.7	14.8
743-22	10	>17	20.8	21.4	21.4	7	17	12.3	10	10	17	13.5	10	17	16.3	13.5	10	17	21.4
743-23	>7.8	>7.8	7.8	8.4	8.4	0													
743-24	9.5	13	22.5	23.5	23.5	3.5	13	10.7	9.5	9.5	13	11.3	9.5	13	12.3	11.3	9.5	13	23.5

Table A-2 (continued)

Suggested Placement bgs by Probe Type																
Type A Well ID	Top of Waste	Bottom of Waste	Max Logged Depth	Drilling Total Depth	Depth to Basalt	Waste Zone Thickness	Tensiometer			Soil Moisture Probe			Lysimeter			Oxidation- Reduction Potential
							T1	T2	T3	M1	M2	M3	L1	L2	Vapor Port VP1 VP2 VP3	
743-25	>17.3	>17.3	17.3	17.8	17.8	0										
743-32	>12	>12	12	12.1	12.1	0										
743-33	>11.4	>11.4	11.4	12.1	12.1	0										
743-34	>11.3	>11.3	11.3	11.9	11.9	0										
743-35	9.3	10.7	15.8	16.4	16.4	1.4	10.7	9.8	9.3	10.7	10.0	9.3	10.7		10	10.0 9.3
43-36	7	17	15.4	25.7	25.7	10	17	10.3	7	17	12.0	7	17		16.3 12.0 7	17 25.7
743-37	8.6	18.5	25.5	25.8	25.8	9.9	18.5	11.9	8.6	18.5	13.6	8.6	18.5		17.8 13.6 8.6	18.5 25.8
743-38	6.7	11.6	14.9	15.5	15.5	4.9	11.6	8.3	6.7	11.6	9.2	6.7	11.6		10.9 9.2 6.7	11.6 15.5
743-39	6.7	11.7	23.3	23.6	23.6	5	11.7	8.4	6.7	11.7	9.2	6.7	11.7		11 9.2 6.7	11.7 23.6
743-40	5.8	13.8	19.8	20.1	20.1	8	13.8	8.5	5.8	13.8	9.8	5.8	13.8		13.1 9.8 5.8	13.8 20.1
743-41	.8	15.2	22.	NA	22.7	3.4	15.2	12.9	11.8	15.2	13.5	11.8	15.2		14.5 13.5 11.8	15.2 22.7
743-42	8.4	14.7	21.9	22.2	22.2	6.3	14.7	10.5	8.4	14.7	11.6	8.4	14.7		14 11.6 8.4	14.7 22.2

Appendix B

Examples of Typical Sample Management Office Sample Plan Tables Used for the First Round of Sampling in the Pits

Plan Table Number SDAPROBING

SAP Number INEEL/EXT-2000-01435

Date 03/07/2001

Plan Table Revision 0.0

Project RWMC

Project Manager BAUMER, A. R.

SMO Contact MCGRIFF, T. W.

Sample Description					Sample Location		Enter Analysis Types (AT) and Quantity Requested																						
Sampling Activity	Sample Type	Sample Matrix	Coil Type	Sampling Method	Planned Date	Area	Location	Type of Location	Depth (ft)	AT1	AT2	AT3	AT4	AT5	AT6	AT7	AT8	AT9	AT10	AT11	AT12	AT13	AT14	AT15	AT16	AT17	AT18	AT19	AT20
IP1.001	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.002	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.003	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.004	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.005	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.006	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.007	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.008	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.009	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.010	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.011	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.012	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.013	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.014	REGDOC	GROUND WATER	DUP	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	2	2																		
IP1.015	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.016	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		
IP1.017	REG	GROUND WATER	GRAB	LYS	04/23/2001	RWMC	SDA	LYSIMETER	TBD	1	1																		

1. Analysis Suite #1

2. Appendix IX VOAs

3. Appendix IX VOAs MSMSD

4. Nitrate/Nitrite - Speciated

5. Radiochemistry - Suite 1

6. VOCs (Mod. TO-14)

7.

8.

9.

AT20:

The sampling activity displayed on this table represents the first six characters of the sample identification number.

The complete sample identification number (10 characters) will appear on field guidance forms and sample labels.

AT1:

AT12:

AT13:

AT14:

AT15:

AT16:

AT17:

AT18:

AT19:

Comments:

The duplicate and VOA MSMSD samples are considered opportunistic and will be taken only if adequate volume is collected for all other requested analyses first. Additionally, if adequate volume is collected from a different sampling location, the sample ID numbers for the duplicate and VOA MSMSD samples may be changed on the day of sampling.

Metal (TAL) is defined as Appendix IX metals except mercury and lead.

Appendix IX VOA list does not include all Appendix IX compounds but is a modified list currently used by the lab (INTEC).

A priority list of analyses based on collected volume has been established in the SOW for this project.

The sampling activity displayed on this table represents the first six characters of the sample identification number. The complete sample identification number (10 characters) will appear on field guidance forms and sample labels.

Comments:

AT1: Analysis Suite #1
 AT2: Appendix IX VOA's
 AT3: Appendix IX VOA's MSMSD
 AT4: Nitrate/Nitrite - Speciated
 AT5: Radiochemistry - Suite 1
 AT6: VOCs (Mod. TO-14)
 AT7:
 AT8:
 AT9:
 AT10:
 AT11:
 AT12:
 AT13:
 AT14:
 AT15:
 AT16:
 AT17:
 AT18:
 AT19:
 AT20:
 Analysis Suites

The duplicate and VOA MSMSD samples are considered opportunistic and will be taken only if adequate volume is collected for all other requested analyses first. Additionally, if adequate volume is collected from a different sampling location, the sample ID numbers for the duplicate and VOA MSMSD samples may be changed on the day of sampling.

Metals (TAL) is defined as Appendix IX metals except mercury and lead.

Appendix IX VOA list does not include all Appendix IX compounds but is a modified list currently used by the lab (INTEC).

A priority list of analyses based on collected volume has been established in the SOW for this project.

Contingencies:

Analysis Suite #1 includes: Am-241, C-14, Tc-99, Metals (TAL), Np-237, Gamma Spec, Pu-Isop, Tritium, U-Isop, Iodine-129

Radiochemistry - Suite 1 includes: C-14, Tc-99, Ni-59, Nb-94, Nd-63, Gamma Spec, Tritium

Appendix C

Information Used to Evaluate Errors in Volatile Organic Contaminant Gas Concentrations from Known Interferent Gases

Information Used to Evaluate Errors in Volatile Organic Contaminant Gas Concentrations from Known Interfering Gases

Immunity to interfering species is an important consideration to mitigate interference during analysis. Concentration and type of potentially interfering gases are important aspects in optical filter selection. Therefore, previous analytical data from the soil gas surveys around the Subsurface Disposal Area (SDA) were evaluated to support selection of optical filters. The highest concentration of volatile organic compounds (VOCs) detected in shallow soil gas (1998 survey at Pit 4) has been detected using a Brüel & Kjaer (B&K) Model 1302 and, as a result, has been limited to the five gases that the unit was set up to evaluate (i.e., the organic contamination in the vadose zone [OCVZ] suite). Gas chromatography/mass spectrometry gas data was also collected from wells sampled outside of the waste between 1994 and 1997, and also used in this evaluation. The highest concentrations detected from any of these data sets were used to evaluate the effects of the potentially interferent gases on the five VOCs of interest. Tables C-1, C-2, and C-3 are all set up, as follows.

Column 1 contains the 10 VOCs detected in the surveys described above. The first five are the “OCVZ suite,” which had all been detected in shallow soil gas immediately above the waste. The second grouping of five compounds, or those below the row dividing line, were additional compounds detected in monitoring wells around the SDA (i.e., further from the source). It is assumed that these compounds are also present in the shallow soil gas, however, data could not be obtained to prove this assumption.

The first column of concentration data (titled: Maximum Previous Concentration [ppm]) is the maximum level detected from the monitoring described above. The fourth column (titled: Estimated Type B Concentration [ppm]) gives typical concentrations assumed from samples that will be collected in the waste using Type B vapor ports. The following are concentration assumptions.

- A multiplication factor of 5x was used for the first five gases, resulting in an expected Type B concentration for carbon tetrachloride of over 30,000 ppm, which is assumed to be reasonable
- A larger multiplication factor of 20x was used for the second five gases, because the sampling was conducted at a greater distance from the source.

The sixth column lists the optical filters selected by the instrument manufacture’s U.S. representative (California Analytical Instruments) to best evaluate the five VOCs of interest with the minimum interference from the listed potential interferent gases. The seventh column gives the optimal analytical detection range for which the instrument is calibrated, using the selected optical filters. The following five columns give the detection level (ppm) on each of the selected optical filters for each of the VOCs anticipated to be present within the waste.

The last five columns state the calculated contribution of the interferent gas in ppm, from the compounds indicated in each row on the left side of the table, to each of the five compounds of interest (designated as the final five column headings). These are calculated using the estimated Type B concentration data for the interferent gases, the optical filter detection level data, and an assumption of the cross compensation gained from the instrument’s software.

The effects of the cross compensation are given separately in the three tables. The assumptions on “measured” concentration resulting from no internal software correction (called cross compensation) are given in Table C-1. The use of the software cross compensation with assumptions on its uncertainty reduction, which the vendor has stated ranges between 90 and 95%, are given in the Tables C-2, and C-3.

Table C-1, representing calculated data generated assuming no instrument cross compensation, indicates concentration overestimation errors ranging from 24.1 to 1,183%. Table C-3, representing cross compensation of 95%, indicates overestimation errors of between 1.2 and 59.1%. Table C-2 assumes 90% cross compensation effectiveness and results in overestimation errors of between 2.4 and 118% for the five compounds of interest.

The data contained in Table C-2 was chosen to describe other aspects of inputs to sensitivity of the overestimation error. For example, three compounds known to exist within the pits provide unwanted interference on the optical filter (UA 0976) selected for tetrachloroethene evaluation. The largest contributor to this "overestimation error" comes from the effect of the assumed high trichloroethene concentration (7,950 ppm) on the UA 0976 filter as an interferent gas. The relatively high value of trichloroethene will increase apparent tetrachloroethene concentrations by approximately 454 ppm, resulting in an apparent concentration more than 100% greater than the true concentration used in this example of 393 ppm. Error is also expected from 1,1,1-trichloroethane and 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113) on the optical filter used for carbon tetrachloride estimation, though its contribution adds less than 7% to the true concentration.

Recognizing the source of error is key to understanding the limitations of this equipment. It is expected that data generated from this instrument, as well as results from samples collected from the pits for gas chromatography/mass spectrometry analysis, will be used to provide a better estimate of error from this instrument in the future. This additional data may result in interest to further optimize filter selection.

Table C-1. Evaluation of interferent gases on measured concentration, assuming no software cross compensation.

Table C-1: Estimation of Interferent Gases on measured concentrations assuming the software does compensation																								
Compound Name	Formula	Molecular Weight	Maximum Previous Concentration (ppm)	Estimated Type B Concentration (ppm)	Optical Filter	Range (ppm)	Optical Filter and Detection Level (ppm)						Contribution of Interferent Gas (Row) to Compound of Interest (Column) (ppm)											
							UA 0936	UA 0971	UA 0974	UA 0975	UA 0976	CCl ₄	CHCl ₃	1,1,1-TCA	TCE	PCE								
Carbon tetrachloride	CCl ₄	153.8	7,260	36,300	UA 0936	6 to 100,000	6	0	21	7	16													
Chloroform	CHCl ₃	119.4	1,550	7,750	UA 0971	1 to 10,000	0	1	0	0	0													
1,1,1-Trichloroethane (1,1,1-TCA)	C ₂ H ₃ Cl ₃	133.4	208	1,040	UA 0974	.09 to 9,000	0.6	0	0.09	1.2	8													
Trichloroethene (TCE)	C ₂ HCl ₃	131.4	1,590	7,950	UA 0975	0.3 to 10,000	0	0	4	0.3	0.07													
Tetrachloroethene (PCE)	C ₂ Cl ₄	165.8	78.5	393	UA 0976	.04 to 4,000	0	0	0	0	0.04													
1,1,2-Trichlor-1,2,2-trifluoroethane	C ₂ Cl ₃ F ₃	187.4	8.2	164	NA	NA	0.07	0.02	0.05	0.5	5	14,057	8,200	295	98	1								
1,1-Dichloroethene	C ₂ H ₂ Cl ₂	96.94	0.79	16	NA	NA	0	0.15	0	1	0.21		105		5	3								
1,3,5-Trimethylbenzene	C ₉ H ₁₂	120.2	0.044	1	NA	NA	0	0	0	0	0													
Propane	C ₃ H ₈	44.1	0.84	17	NA	NA	10	5.5	5	0	11	10	3.1	0.30		0								
2-Octanone	C ₈ H ₁₆ O	128.2	12	240	NA	NA	0	0	0	0	0													
Reduction in uncertainty by software calculation							True concentration (ppm)													36,300	7,750	1,040	7,950	393
							Measured concentration (ppm)													60,767	16,058	1,670	9,869	5,036
							Overestimation error (%)													67.4%	107.2%	60.6%	24.1%	1183.0%

0%

Table C-2. Evaluation of interferent gases on measured concentration, assuming 90% software cross compensation.

Table C-27. Evaluation of Interferent Gases on measured concentrations assuming 90% software error compensation																
Compound Name							Optical Filter and Detection Level (ppm)					Contribution of Interferent Gas (Row) to Compound of Interest (Column) (ppm)				
							Maximum Previous Concentration (ppm)	Estimated Type B Concentration (ppm)	Optical Filter	Range (ppm)	UA 0936				UA 0971	UA 0974
Carbon tetrachloride	CCl ₄	153.8	7,260	36,300	UA 0936	6 to 100,000	6	0	21	7	16					
Chloroform	CHCl ₃	119.4	1,550	7,750	UA 0971	1 to 10,000	0	1	0	0	0					
1,1,1,1,1-Trichloroethane (1,1,1,1-TCA)	C ₂ H ₃ Cl ₃	133.4	208	1,040	UA 0974	0.09 to 9,000	0.6	0	0.09	1.2	8	1,040				
Trichloroethene (TCE)	C ₂ HCl ₃	131.4	1,590	7,950	UA 0975	0.3 to 10,000	0	0	4	0.3	0.07		18			
Tetrachloroethene (PCE)	C ₂ Cl ₄	165.8	78.5	393	UA 0976	0.04 to 4,000	0	0	0	0	0.04					
1,1,1,2-Trichloro-1,2,2-trifluoroethane	C ₂ Cl ₃ F ₃	187.4	8.2	164	NA	NA	0.07	0.02	0.05	0.5	5	1,406	820	30		
1,1,1,1-Dichloroethene	C ₂ H ₂ Cl ₂	96.94	0.79	16	NA	NA	0	0.15	0	1	0.21		11			
1,3,5-Trimethylbenzene	C ₉ H ₁₂	120.2	0.044	1	NA	NA	0	0	0	0	0					
Propane	C ₃ H ₈	44.1	0.84	17	NA	NA	10	5.5	5	0	11	1	0.3	0.03		
2-Octanone	C ₈ H ₁₆ O	128.2	12	240	NA	NA	0	0	0	0	0					
Reduction in uncertainty by software calculation 90%							True concentration (ppm)					36,300	7,750	1,040	7,950	393
							Measured concentration (ppm)					38,747	8,581	1,103	8,142	857
							Overestimation error (%)					6.7%	10.7%	6.1%	2.4%	118.3%

Table C-3. Evaluation of interferent gases on measured concentration, assuming 95% software cross compensation.

TABLE C-5. Evaluation of Interferent Gases on measured concentrations, assuming 95% software cross compensation.										Contribution of Interferent Gas (Row) to Compound of Interest (Column) (ppm)											
Compound Name							Optical Filter and Detection Level (ppm)					Contribution of Interferent Gas (Row) to Compound of Interest (Column) (ppm)									
							Formula	Molecular Weight	Maximum Previous Concentration (ppm)	Estimated Type B Concentration (ppm)	Optical Filter						Range (ppm)	UA 0936	UA 0971	UA 0974	UA 0975
Carbon tetrachloride							CCl ₄	153.8	7,260	36,300	UA 0936	UA 0971	UA 0974	UA 0975	UA 0976	CCl ₄	CHCl ₃	1,1,1-TCA	TCE	PCE	
Chloroform							CHCl ₃	119.4	1,550	7,750	UA 0971	0	0	0	0						
1,1,1,1,1-Trichloroethane (1,1,1-TCA)							C ₂ H ₃ Cl ₃	133.4	208	1,040	UA 0974	0	0.09	1.2	8	520		13	0		
Trichloroethene (TCE)							C ₂ HCl ₃	131.4	1,590	7,950	UA 0975	0	4	0.3	0.07		9		227		
Tetrachloroethene (PCE)							C ₂ Cl ₄	165.8	78.5	393	UA 0976	0	0	0	0.04						
1,1,1,2-Trichlor-1,2,2-trifluoroethane							C ₂ Cl ₃ F ₃	187.4	8.2	164	NA	0.07	0.02	0.05	0.5	5	703	410	15	5	0
1,1,1-Dichloroethene							C ₂ H ₂ Cl ₂	96.94	0.79	16	NA	0	0.15	0	1	0.21		5		0	0
1,3,5-Trimethylbenzene							C ₉ H ₁₂	120.2	0.044	1	NA	0	0	0	0	0					
Propane							C ₃ H ₈	44.1	0.84	17	NA	10	5.5	5	0	11	1	0.2	0.02		0
2-Octanone							C ₈ H ₁₆ O	128.2	12	240	NA	0	0	0	0	0					
Reduction in uncertainty by software calculation							True concentration (ppm)										36,300	7,750	1,040	7,950	393
							Measured concentration (ppm)										37,523	8,165	1,071	8,046	625
							Overestimation error (%)										3.4%	5.4%	3.0%	1.2%	59.1%

Appendix D

Type A Logging Data Used to Site Type B Probe Clusters

INTEROFFICE MEMORANDUM

Date: December 6, 2000

To: A. R. Baumer MS 3920 6-3238

From: J. W. Mandler MS 2114 6-0355
J. R. Giles MS 3950 6-4158

Subject: OPERABLE UNIT 7-13/14 DEPLETED URANIUM AND 741 STUDY AREA
PROBEHOLE RECOMMENDATIONS

INTRODUCTION AND OBJECTIVES

This letter report recommends locations for installing additional Type A probeholes in the Depleted Uranium (DU) and 741 Sludge study areas within Pit 10 of the Subsurface Disposal Area (SDA). The recommended locations comprise probe clusters that will permit detailed evaluation of DU and 741 contamination source terms within localized areas. These recommendations are based on a detailed review of subcontractor-supplied downhole logging results along with limited additional logging data analysis.

The OU 7-13/14 Work Plan specifies the need to develop improved understanding of the long-term health and safety risk associated with uranium and neptunium waste at the SDA. The solubility of uranium and neptunium are important factors in developing realistic models of long-term risk. An initial exploration probing and logging campaign at Pit 10 was designed to identify uranium and neptunium bearing waste zones that can be used to study solubility issues.

The DU and 741 study areas were selected based on the expectation that these areas would contain uranium and neptunium-bearing waste (Figure 1). A suite of logging measurements including passive and active gamma-ray and neutron methods were performed in the exploration boreholes. Subcontractor-supplied logging data were reviewed to select locations for follow-up detailed studies. These detailed studies will be executed by installing probe clusters to facilitate sample collection, groundwater monitoring, and additional logging in a localized area. This report presents the recommended locations for the Type A probe clusters. Once installed, the cluster probes will be logged and the data will be used to quantify the uranium and neptunium source term within each localized area.

Analysis Methods

GTS results

The logging subcontractor conducted preliminary processing of the DU and 741 study area logging data. Their processing included automated spectral analysis of passive gamma-ray data to identify the presence

of specific target contaminants including ^{235}U , ^{238}U , ^{239}Pu , ^{241}Am , and ^{237}Np ⁱ. After applying a standard calibration correction to convert net count rates to apparent radionuclide concentrations^j, summary results were compiled and delivered to the INEEL along with the raw spectral data.

The subcontractor summary results were organized into a comprehensive database to facilitate review. Tables 1 and 2 present the maximum apparent concentrations for the key contaminants in the two study areas. In addition, selected gamma-ray ratios were computed to help assess the nature of the uranium and neptunium waste mixtures (see Appendix C).

Table 1. Summary of maximum measured contamination levels for the DU study area.

Probe Identification	Total Depth	Max U238 (pCi/g)	Max U235 (pCi/g)	Max Pu239 (nCi/g)	Max Am241 (nCi/g)	Max Pa233 (pCi/g)
DU-01	14.3	91	1	-	-	-
DU-02	14.8	117	6	33	179	5
DU-03	14.5	1979	14	-	-	-
DU-04	14.0	-	-	-	128	-
DU-05	18.3	97	-	-	-	-
DU-06	18.5	45	-	-	-	-
DU-07	14.5	-	-	64	41	-
DU-08	18.4	469	18	4944	-	4881

Table 2. Summary of maximum measured contamination levels for the 741 study area.

Probe Identification	Total Depth	Max U238 (pCi/g)	Max U235 (pCi/g)	Max Pu239 (nCi/g)	Max Am241 (nCi/g)	Max Pa233 (pCi/g)
741_01	5.9	<i>NOT LOGGED</i>				
741_02	18.1	-	-	2084	13106	422
741_03	20.7	-	-	782	7938	244
741_04	24.3	-	-	1065	5509	172
741_05	6.2	<i>NOT LOGGED</i>				
741_06	18.0	681	84	1504	2386	72
741_07	6.3	<i>NOT LOGGED</i>				
741_08	21.8	-	-	8058	8874	311
741_09	14.3	267	28	-	-	-

i. ^{237}Np detection based on gamma-ray from short-lived daughter ^{233}Pa ; ^{238}U determined based on $^{234\text{m}}\text{Pa}$.

j. Subcontractor calibration corrections assume homogenous, isotropic, soil matrix.

Spectral analysis

In general, the raw spectral files for the DU and 741 study areas were not reviewed for this report since the primary recommendations are qualitative in nature. In a few cases spectra were reviewed to identify secondary gamma-rays as a means to clarify subcontractor interpretations based on primary gamma-rays.

Cluster Probe Recommendations

Cluster probe recommendations are based on a conceptual model of uranium and neptunium target distributions as herein described. Nuclear logging methods for uranium and neptunium have a relatively limited volume of investigation (approx. 0 – 1 ft). The logging tool may pass through or alongside one or more source volumes during logging operations in any probe. The logging instruments will record increased gamma-ray activity only if some part of a source volume occurs within the volume of investigation of the logging tool. For purposes of this interpretation, we assume that the measured logging response at any given depth is influenced by a single source distribution having a total volume less than or equal to the volume of a 55-gal drum (approx. 9 ft³). Thus, in the absence of more complex analysis, each gamma-ray peak recorded in the logging data is considered to reflect the presence of a single waste drum that may be used as a target for cluster probe study.

The recommended cluster probe geometry consists of six equally spaced probes forming a ring around the probe of interest (see Figure 2). The cluster probe pattern has a footprint of 3 x 3 ft, and is well suited to intersect and surround a target volume of 9 ft³. In addition, the spacing between probes is 1.5 ft, so that the volume of investigation for adjacent probes will intersect slightly.

DU Area

The primary recommended cluster probe target in the DU study area occurs in probehole DU-03 at a depth of 9.0 ft. This zone has the following attributes:

- Both ²³⁸U and ²³⁵U observed in high concentrations compared with other DU area probeholes
- ²³⁵U/²³⁸U ratios consistent with depleted uranium^k
- No other intermixed contamination observed
- Reduced contamination level for several ft below high contamination zone provides convenient conditions for leachate collection and migration studies.

The secondary recommended cluster probe target in the DU study area occurs in probehole DU-08 at a depth of 12.5 ft. This zone has the following attributes:

- Both ²³⁸U and ²³⁵U observed in high concentrations compared with other DU Area probeholes
- ²³⁵U/²³⁸U ratios consistent with natural uranium
- Pu/Am/Np occurs within same depth zone as ²³⁵U/²³⁸U
- ²³⁵U/²³⁸U occurs near bottom of hole.

k. ²³⁵U/²³⁸U ratios also depend on the position of the source relative to the logging tool, since ²³⁵U and ²³⁸U gamma-rays are attenuated differently in soil media

Table 3 gives coordinates for the primary and secondary DU area cluster probes.

741 Area

The primary recommended cluster probe target in the 741 study area occurs in probehole 741-08 at a depth of 8.0 ft. This zone has the following attributes:

- Pu/Am/Np observed in high concentrations compared with other 741 Area probeholes
- Single, narrow Pu/Am/Np contamination zone with no other intermixed contamination observed
- Zone shows significant ^{237}Np enrichment relative to the amount expected from the decay of pure ^{241}Am
- Reduced contamination level for 10 ft below high contamination zone provides convenient conditions for leachate collection and migration studies.

The secondary recommended cluster probe target in the 741 study area occurs in probehole 741-02 at a depth of 10.5 to 11.5 ft. This zone has the following attributes:

- Pu/Am/Np observed in high concentrations compared with other 741 area probeholes
- Single, broad Pu/Am/Np contamination zone with no other intermixed contamination observed
- Zone shows significant ^{237}Np enrichment relative to the amount expected from the decay of pure ^{241}Am
- Reduced contamination level for 5 ft below high contamination zone provides convenient conditions for leachate collection and migration studies

Table 4 gives coordinates for the primary and secondary 741 area cluster probes based on a 1.5 ft probe spacing.

Table 4. Coordinates for recommended cluster probe locations.

Well ID	Easting*	Northing*
DU-03-C1	266215.2	669217.6
DU-03-C2	266216.5	669216.9
DU-03-C3	266216.5	669215.4
DU-03-C4	266215.2	669214.6
DU-03-C5	266213.9	669215.4
DU-03-C6	266213.9	669216.9
DU-08-C1	266214.8	669247.3
DU-08-C2	266216.1	669246.6
DU-08-C3	266216.1	669245.1
DU-08-C4	266214.8	669244.3
DU-08-C5	266213.5	669245.1
DU-08-C6	266213.5	669246.6

Table 4. (continuous)

Well ID	Easting*	Northing*
741-08-C1	266550.2	669186.9
741-08-C2	266551.5	669186.2
741-08-C3	266551.5	669184.7
741-08-C4	266550.2	669183.9
741-08-C5	266548.9	669184.7
741-08-C6	266548.9	669186.2
741-02-C1	266577.1	669186.5
741-02-C2	266578.4	669185.8
741-02-C3	266578.4	669184.3
741-02-C4	266577.1	669183.5
741-02-C5	266575.8	669184.3
741-02-C6	266575.8	669185.8

*Idaho State Plane, East Zone, NAD 27

Azimuthal uncertainty

The existing logging measurements for the DU and 741 study areas contain no information concerning the azimuthal position of the source around the probehole. The recommended cluster probe geometry is designed to accommodate any of the possible locations of the source zone with respect to the target probe. In the event that azimuthal information can be successfully collected within the target zone, and that these data indicate a clear azimuthal position of the contamination source the number of cluster probes may be reduced, and located in the optimal azimuthal direction.

Other Observations

This section documents some additional observations noted during review of the subcontractor data summary. Further details concerning these observations may be found in Appendices A and B.

^{237}Np and ^{241}Am enrichment

Table 5 shows a comparison between expected and observed Pu/Am/Np ratios where the expected values are based on 30-year decay of weapons grade plutonium¹. The observed Am and Np values indicate enrichment relative to Pu for this specific decay scenario. This general condition of Am and Np enrichment was observed throughout the DU and 741 study areas.

1. All ^{241}Am derived from decay of ^{241}Pu , and all ^{237}Np derived from decay of ^{241}Am .

Table 5. Comparison of expected and observed Pu/Am/Np activity ratios.

Ratio	Weapons-grade Pu	Observed
$^{239}\text{Pu}/^{241}\text{Am}$	6.7	0.1; 1
$^{241}\text{Am}/^{233}\text{Pa}$	100,000	33,000
$^{239}\text{Pu}/^{233}\text{Pa}$	1,100,000	2000; 30,000

Elevated ^{232}Th levels

Apparent elevated natural thorium concentrations were observed in several of the probeholes in the 741 Sludge study area, indicating a potential source of Th-228 that was not identified in the interim baseline risk assessment. Probehole 741-2 exhibits the highest observed concentrations of natural thorium at a depth of 12.0 ft and a concentration of 58.41 pCi/g. The elevated thorium in probehole 741-2 spans a depth range from approximately 8.0 ft to 17.0 ft. The elevated thorium is also present in probeholes 741-3, 741-6, 741-8, DU-7 and DU-8, however, the elevated thorium in DU-7 has been determined to be natural thorium (Th-232). It is important to note here that the mean background value for natural thorium in INEEL soils is 1.25 pCi/g (Rood et al. 1996).

Enriched uranium

Enriched, or highly enriched uranium was identified in probeholes 741-6 and 741-9. These zones were identified at the bottoms of the probeholes, separate from any Am-241 or Np-237. Natural uranium or enriched uranium was located far from the probe (see J.W. Mandler's observations and comments).

^{137}Cs

Cesium-137 was identified in probehole 741-4 at a depth interval from 13.0 to 20.0 ft, with a maximum concentration of 139.4 pCi/g at a depth of 16.5 ft. It was determined that this is a true source of Cs-137, as discussed in J.W. Mandler's observations.

Summary

This letter report and appendices represent what is to be considered a minimal data analysis. Based on this analysis, a Type A cluster probe configuration is proposed for each study area of interest including DU-3, DU-8, 741-8 and 741-2. Upon installation of the cluster probes, it is recommended that both the conventional GTS logs and the azimuthal logs should be completed followed by a more detailed data analysis than what was presented here. This is required for the process of estimating the source term around the selected probeholes, which will support the evaluation of uranium and neptunium solubility.

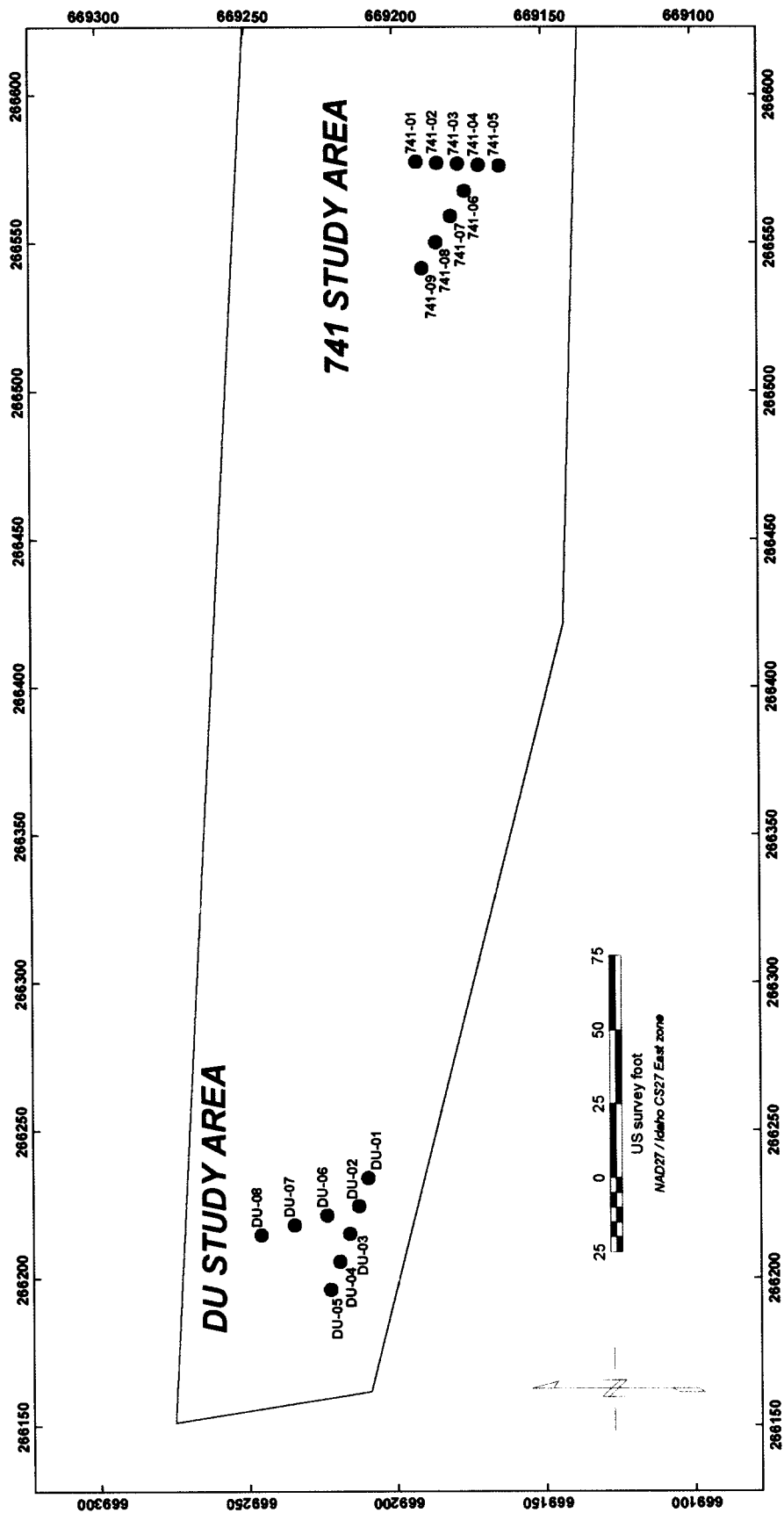


Figure 1. Map showing the DU and 741 study areas in relation to the Pit 10 boundary.

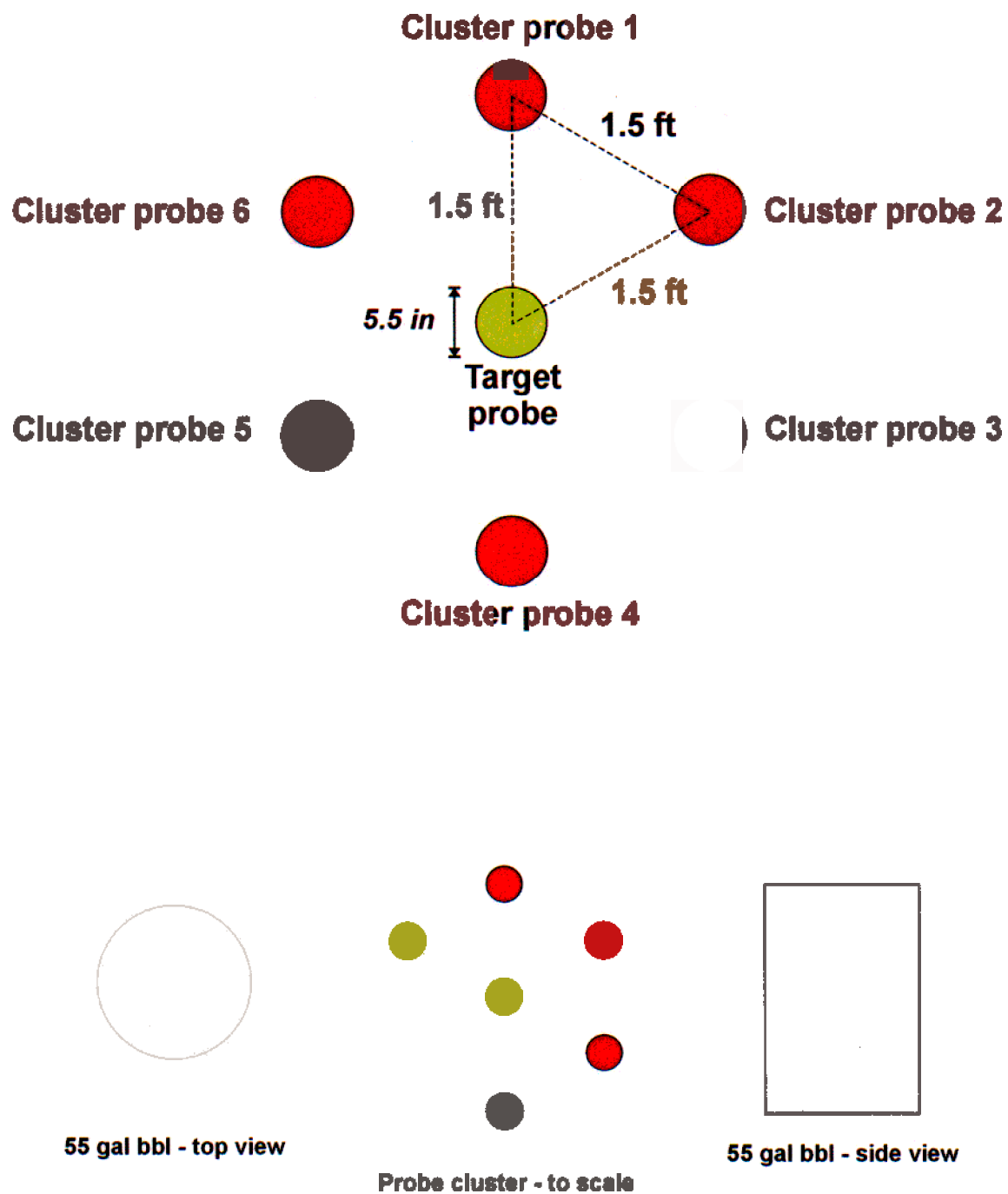


Figure 2. Probe cluster geometry with comparison to 55 gal drum size.

**Summary of DU and 741 Area Azimuthal Logging
Logging data through 5/23/01**

N.E. Josten
6/1/01

Summary of DU and 741 Area Azimuthal Logging Logging data through 5/23/01

N.E. Josten
6/1/01

Introduction

The OU7-13/14 project conducted azimuthal gamma-ray logging in selected probes within the DU, 741 and 743 study areas as a means to investigate the spatial distribution of subsurface radionuclides. Twelve probes were selected for the azimuthal surveys based on existing geophysical logging data. These probes were selected because they contained high levels of either ^{238}U or ^{237}Np (see Table 1).

Table 1. Probeholes selected for azimuthal logging.

Probehole	Depth (ft)	Radionuclide	Max cps*
DU-10	7.5	^{238}U	3253
743-08	22.5	^{238}U	220894
DU-16	11.5	^{238}U	6604
DU-14	13.5	^{238}U	17300
DU-03	8.0	^{238}U	1979
DU-15	11.5	^{238}U	1947
DU-08	14.5	$^{237}\text{Np}^{**}$	4944
741-08	8.0	^{237}Np	316
741-02	11.5	^{237}Np	428
741-04	9.5	^{237}Np	172
741-03	9.5	^{237}Np	244
743-12	15.5	^{237}Np	275

* as observed by standard gamma-ray logging

** ^{237}Np indicated by ^{233}Pa daughter

Azimuthal logging was conducted by GTS Duratek during May, 2001 and preliminary results were delivered to the INEEL on May 31, 2001. Figure 1 shows the cover letter included with the data delivery.

Azimuthal logs were analyzed to choose probes for follow up studies of ^{238}U or ^{237}Np leaching and migration. Azimuthal data were used to indicate the position of ^{238}U or ^{237}Np relative to the probehole so that lysimeters could be installed to collect leachate samples.

Results

For each probe, Table 2 lists detected radionuclides and gives the azimuth of the observed maximum count rate for each. Azimuth is measured with respect to a north arrow marked on the probe casing. Table 2 also gives the approximate maximum count rates and two general qualifiers. The first qualifier describes the statistical significance of the direction indication and

the second qualifier describes the narrowness of the direction indication (i.e. “good” indicates a highly directional source and “poor” indicates a broadly directional source).

The Table 2 data were used to determine the position and target depth for Type B probes. These data may also be used to choose locations for additional Type A probes in the event that it becomes necessary to model the radionuclide source distribution in detail.

Table 2. Azimuthal data summary.

Probe	Depth (ft)	Nuclide @ azimuth	Max cps	Statistics	Direction
DU-10	7.5	^{238}U @ 190°	4	Good	Good
743-08	22.5	^{238}U @ 200°	120	Good	Poor
		^{235}U @ NA	2.5	Poor	Poor
DU-16	11.5	^{238}U @ 135°	2.5	Fair	Good
		^{238}U @ 270°	1.8	Good	Good
		2614 keV @ 235°	3.3	Good	Good
DU-16	13.5	^{238}U @ 130°	5.5	Good	Good
DU-14	8.0	^{238}U @ 65°	21	Good	Good
		^{238}U @ 200°	11	Good	Fair
DU-14	10.0	^{238}U @ 190°	1.1	Fair	Good
		^{239}Pu @ 45°	0.7	Fair	Good
DU-03	8.5	^{238}U @ 140°	1.4	Fair	Fair
DU-15	13.5	^{239}Pu @ 315°	75	Good	Good
DU-15	15.5	^{238}U @ 35°	1.7	Good	Good
DU-08	12.5	^{238}U @ 350°	0.5	Good	Good
DU-08	14.5	^{233}Pa @ 190°	14	Good	Good
741-08	8.0	^{233}Pa @ 125°	2.5	Fair	Good
		^{241}Am @ 115°	3.5	Fair	Fair
		^{239}Pu @ NA	2.8	Good	Poor
741-02	11.5	^{233}Pa @ 85°	5.5	Good	Fair
		^{241}Am @ 80°	6.2	Good	Fair
		^{239}Pu @ 85°	0.6	Poor	Good
		583 keV @ 80°	0.8	Fair	Fair
741-04	9.5	^{233}Pa @ 200°	1.4	Good	Poor
		^{241}Am @ 205°	2.0	Good	Poor
		^{239}Pu @ 180°	0.4	Poor	Good
741-03	9.5	^{233}Pa @ 35°	2.4	Good	Fair
		^{241}Am @ 35°	3.3	Good	Fair
743-12	15.5	^{239}Pu @ 180°	29	Good	Poor

May 29, 2001

To: Nick Josten
Geo Sense
2742 St. Charles Ave.
Idaho Falls, Idaho 83404

From: Jim Meisner
Duratek Federal Service, Inc.
345 Hills St.
Richland, Washington 99352

Subject: Geophysical Log Data from RWMC Pit 5 Boreholes and P9-20. 743-08

Enclosed you will find preliminary results of the May 13-23, 2001 logging campaign with four geophysical log types (azimuth, neutron-moisture, passive-neutron, and neutron-gamma). The azimuth surveys were acquired at selected depths in predetermined probe holes. The neutron-moisture, passive-neutron and a partial set of the neutron-gamma surveys were acquired in the RWMC Pit 5 probe holes and the six delineation probe holes installed around P9-20 and 743-08. The remaining surveys (i.e. passive-gamma and neutron-gamma) will be collected on the next logging campaign.

The azimuth survey results are presented as both a polar and an x-y cartesian plot of azimuth direction versus activity. The cartesian plot count rate activity (y-axis in counts per second) includes error bars at two sigma level (95% confidence interval). The total gamma activity plot is included for consistency with previous azimuth survey results. Also, note that the net gamma ray count rates are now better with the improved azimuth shield. Therefore, future azimuth survey plot results will feature the net gamma ray count rates and will not include the total gamma plots.

The north direction was not marked on some of the casing for the azimuth survey. In these cases, the logger estimated north and placed a mark on the casing for the azimuth survey. A comment is included on the corresponding azimuth survey plots.

The azimuth survey results for DU-08 at 14.5 ft, 312 keV (Pa-233) are different than expected. The 312 keV gamma ray attenuation through the shield is excessive. Other physical processes are occurring. No other azimuth surveys exhibit this condition. Investigation to identify the cause is recommended.

An Excel file is included that identifies the borehole numbers, depth, and initial date each probe type was run for the new probe holes being logged.

The results include survey plots (hard copy) and electronic data files:

1. Plots of neutron moisture and passive neutron are presented as 2 log tracks on one page for each borehole. The background neutron activity has been subtracted from the moisture results.
2. CD-ROM disk contains:
 - Raw survey data (Ortec -.CHN files compressed into WinZip format),
 - Preliminary survey results in Microsoft Excel spread sheet format,
 - Graphical presentation of survey data (sigma plot format and window-meta-file format), and
 - Microsoft Word document file of data plots.

Figure 1. GTS Duratek data submittal cover letter.

**Summary of DU and 743 Study Area logging results
through 2/5, w/ emphasis on new logging data received 1/29/01**

N. E. Josten
2/6/01

**Summary of DU and 743 Study Area logging results through 2/5,
w/ emphasis on new logging data received 1/29/01**

N. E. Josten
2/6/01

DU AREA

Logging status

- ✓ 9 new probes (DU-09 through DU-17)
- ✓ gamma logs – 9/9 complete
- ✓ moisture logs – 9/9 complete
- ✓ neutron logs – 9/9 complete
- ✓ n-gamma logs – 3/9 complete

Results

The table below gives maximum detected levels of key target contaminants for all DU Area probes. NL indicates “not logged.” Blank cells indicate non-detects.

Well ID	Cl 1165 cps	Cl 6111 cps	U235 186 pCi/g	U238 1001 pCi/g	Pu239 414 nCi/g	Am241 662 nCi/g	Pa233 312 pCi/g
DU-01	23	10	1	91			
DU-02	5	3	6	117	33	179	5
DU-03	20	8	14	1979			
DU-04						128	
DU-05	2	1		97			
DU-06	22	10		45			0
DU-07	4	3			64	41	
DU-08	21	9	18	469	4944		4881*
DU-09	21	8					
DU-10	10	4		3253			
DU-11	11	4	11	1139	776	58	1
DU-12	NL	NL	2	36	12		2
DU-13	NL	NL	73	164	804	63	4
DU-14	NL	NL		17300	339	33	
DU-15	NL	NL	17	1947	48699	4878	164
DU-16	NL	NL	9	6604			
DU-17	NL	NL	2	1514	446	46	4

* This apparently anomalous value for Pa-233 has been brought to the attention of GTS

U-238 was more widespread in the new probes than in the original eight probes. Three of the new probes had higher apparent U-238 concentrations than previously observed in the DU study area. DU-14 had an apparent U-238 concentration of 17,300 pCi/g (compared to a previous high in DU-03 of 1979 pCi/g). Based on these new measurements, we may wish to reconsider our Type B probe targets. (See Figure 1.)

U-235 levels observed in the new probes are comparable to those observed in the original eight probes. DU-13 had an apparent U-235 concentration of 73 pCi/g (compared to a previous high in

DU-08 of 18 pCi/g). As before, U235 is often not detected above the noise level even when U238 is prominent. (See Figure 2.)

U-235:U-238 concentration ratios, uncorrected for differential attenuation, show two trends: U235:U238 \approx 0.008:1 and U235:U238 \approx 0.04:1. These ratios are similar to those observed and reported for the original 8 probes, suggesting that we are observing similar waste mixtures. (See Figure 3.)

Pu/Am/Np are observed in various combinations throughout the DU study area, with higher relative amounts of Pu compared to other areas of Pits 4, 9 and 10. Probe DU-15 shows an apparent Pu-239 concentration just under 50,000 nCi/g, or about 25% of the level observed in P9-20. The predominant Am:Pu concentration ratio is 0.12:1, compared with 10.8:1 and 1:1 observed in the 741 study area. As elsewhere in Pits 4 and 10, Am:Pa ratios show a consistent value near 32,000:1. The Am:Pa ratio suggests an excess of Np relative to the amount expected from pure Am decay, but nonetheless in constant proportion to Am. (See Figure 3.)

Locations for probes DU-09 through DU-17 were chosen partly on the basis of surface geophysical data to give a comparison between probes positioned at the peak of geophysical anomalies versus probes located on the flanks of geophysical anomalies. The logging data show that radionuclides were detected in all locations and that variations in apparent radionuclide concentration are unrelated to the geophysical data (Figure 4).

743 AREA

Logging status

- ✓ 11 new probes (743-32 through 743-42)
- ✓ gamma logs – 9/11 complete
- ✓ moisture logs – 2/11 complete
- ✓ neutron logs – 2/11 complete
- ✓ n-gamma logs – 10/11 complete

Results

The table below gives maximum detected levels of key target contaminants for all 743 Area probes. NL indicates “not logged.” Blank cells indicate non-detects.

Well ID	CL 1165 cps	CL 6111 cps	U235 186 pCi/g	U238 1001 pCi/g	Pu239 414 nCi/g	Am241 662 nCi/g	Pa233 312 pCi/g	2614keV cps
743-01	15	6			70			
743-02	27	11	4		206	47		
743-03	35	15			137			
743-04	30	11			1447	3251		5
743-05	27	12		103	1630	10467		23
743-06	30	13			2168	272	9	2
743-07	22	10	19	1582	280	545	14	24
743-08	29	11	345	220894	9005	1857	58	65
743-09	27	12		330	1547	1242	37	5
743-10	32	12	14	714	963	477	14	3
743-11	23	9	20	1064	5958	2048	49	18
743-12	20	10	63		72259	8160	275	
743-13	26	12	7	114	1055	231	5	7

Well ID	Cl 1165 cps	Cl 6111 cps	U235 186 pCi/g	U238 1001 pCi/g	Pu239 414 nCi/g	Am241 662 nCi/g	Pa233 312 pCi/g	2614keV cps
743-14	27	11	35	50	67	120	1	1
743-15	22	8	21		1105	106		
743-16	17	8			1098	162		
743-17	9	4		177	292	89	1	2
743-18	5	2			135			1
743-19								
743-20	4	2		737	602	143		
743-21					763	102		
743-22	2	1			4355	341		
743-23								
743-24	2	1			3531	466	12	
743-25								
743-32	3	1				34		
743-33	0		0					
743-34								
743-35	1	1	NL	NL	NL	NL	NL	NL
743-36	17	9	108	840	13887	1466	32	4
743-37	24	9			90			1374
743-38	16	8			117			
743-39	9	4	NL	NL	NL	NL	NL	NL
743-40	28	12	1	11	98			
743-41	7	4	7			29		
743-42	NL	NL	10					1

New probes show that chlorine concentrations diminish toward the northern Pit 4 boundary. The ISV probes (743-34 through 743-42) show some high chlorine levels comparable to transect probes, and some low (or non-detect) chlorine levels due presumably to the northern limit of waste. Both the 1165 keV and 6111 keV chlorine lines present the same general picture of chlorine distribution (see Figure 5).

U-238 and U-235 are observed throughout the central portion of the main transect (743-05 through 743-17). Probe 743-08 show an apparent U-238 concentration of 220,894 pCi/g, which is an order of magnitude higher than the previous highest U-238 probe (DU-14) and two orders of magnitude greater than the highest levels observed elsewhere in the 743 area.

Pu/Am/Np are observed in various combinations throughout the 743 study area. Probe 743-12 shows an apparent Pu-239 concentration of 72,259 nCi/g, about 33% of the level observed in P9-20.

The logging subcontractor noted elevated 2614 keV gamma ray counts in many of the central and northern transect probes. Elevated 583 keV and 511 keV counts were also reported. According to GTS, these gamma-rays are associated with Tl-208, and they have traced activity from Tl-208 parents up through Pb-212 but no further. Also, GTS reports several other unidentified gamma-rays in probes having Tl-208 gammas. The significance of these observations is not presently understood. Note that all observed 2614 gamma-ray levels are in the range of 1 – 65 cps, except for probe 743-37, which had 1374 cps.

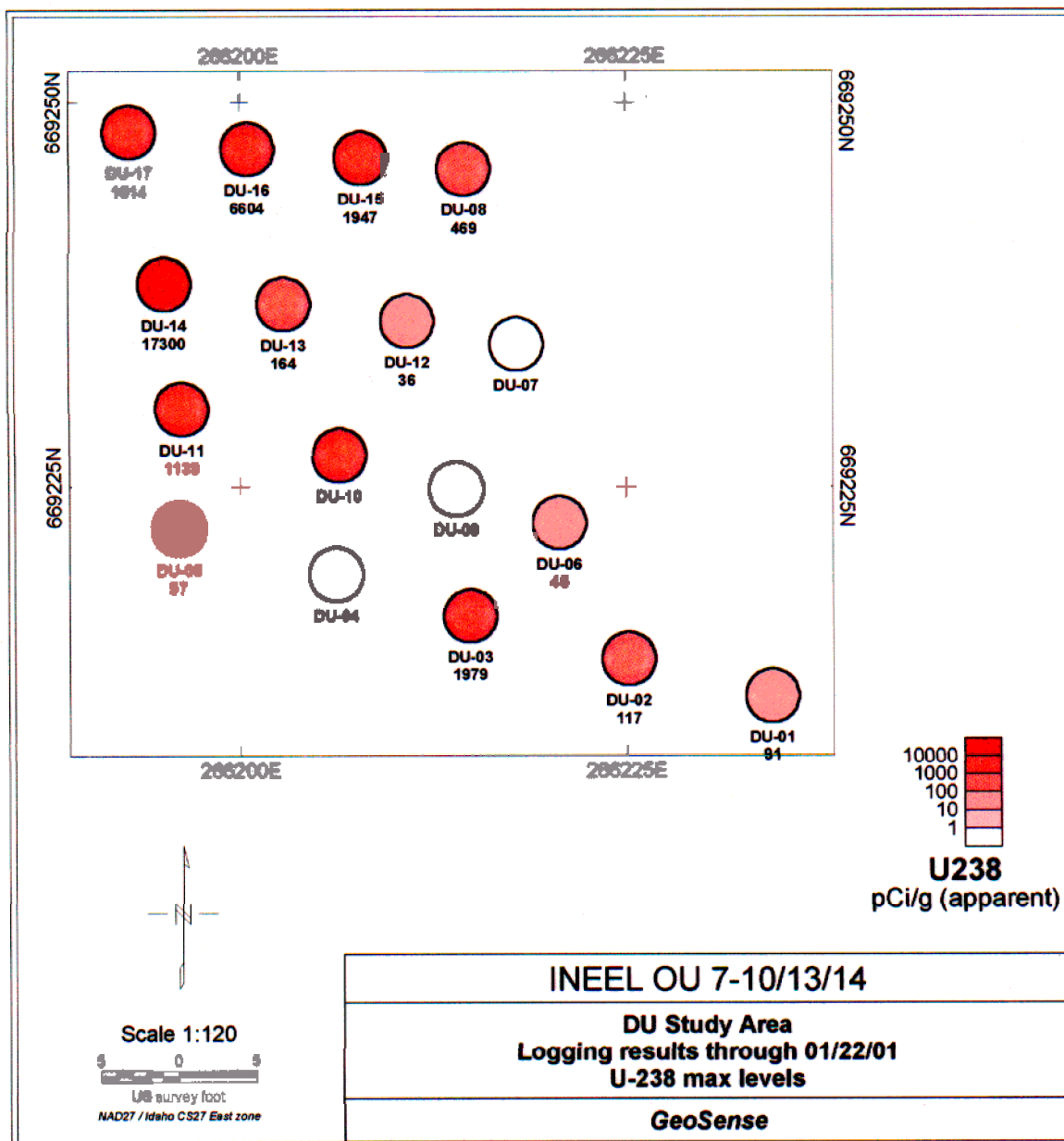


Figure 1. U-238 apparent concentrations.

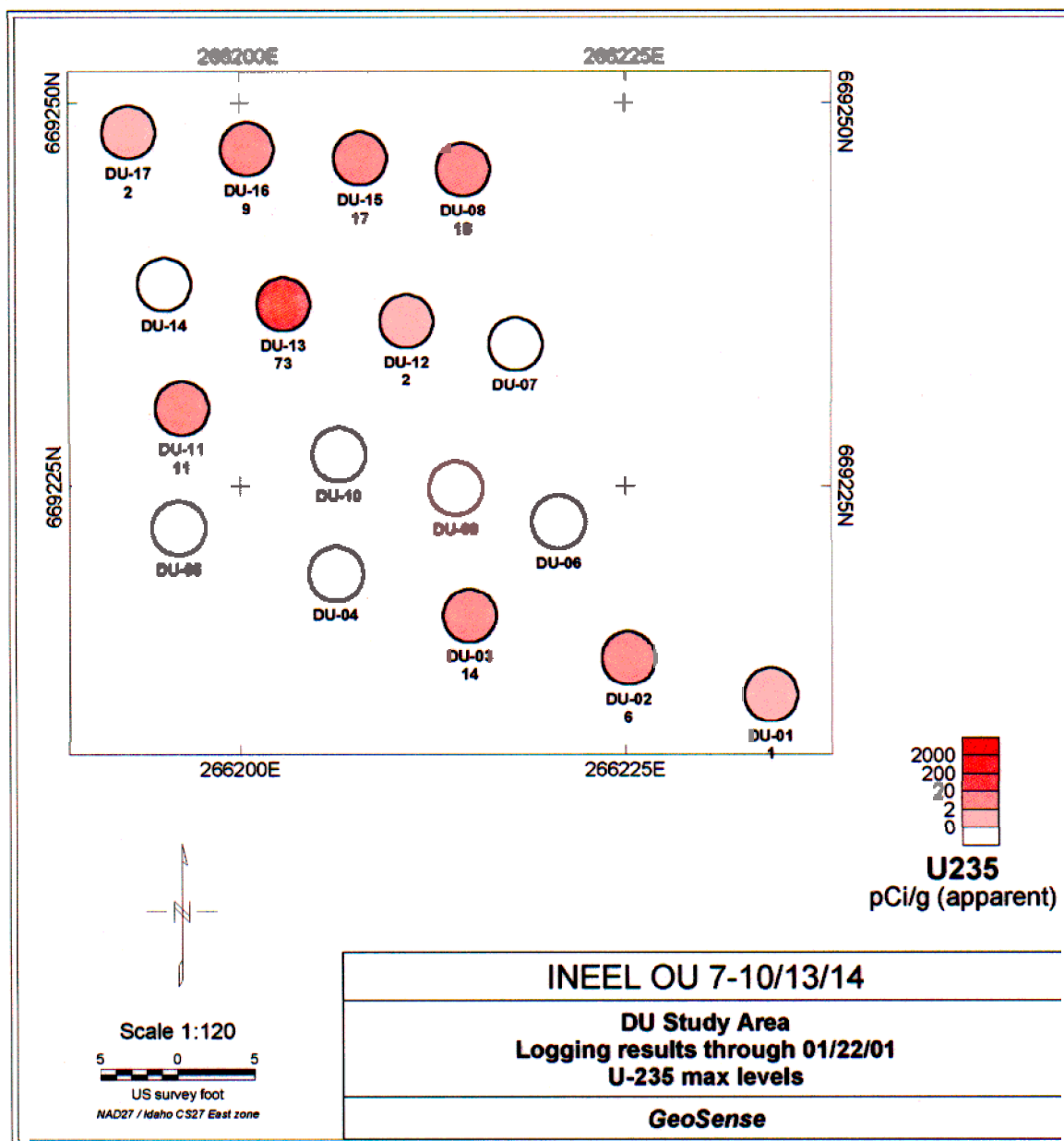


Figure 2. U-235 apparent concentrations.

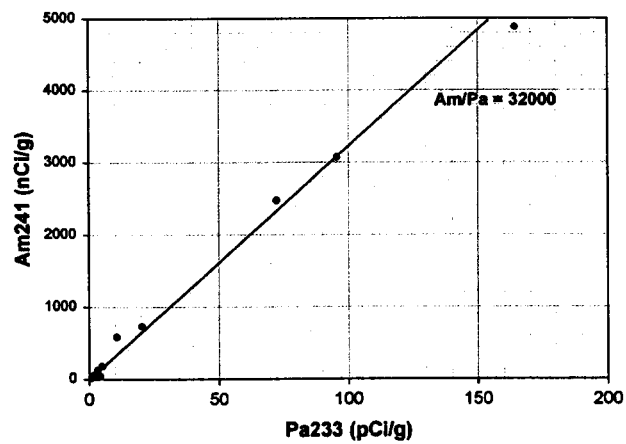
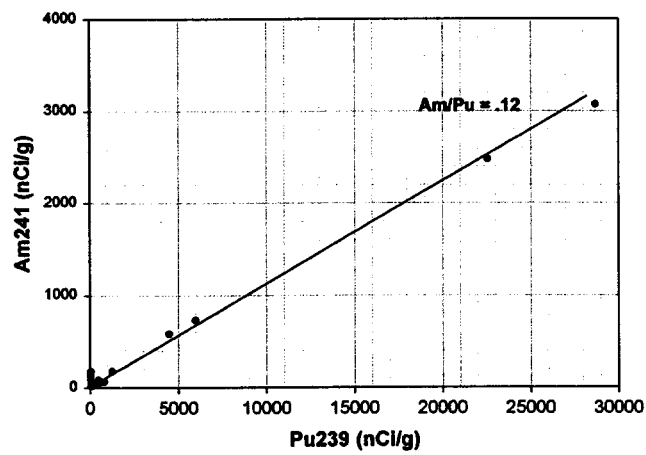
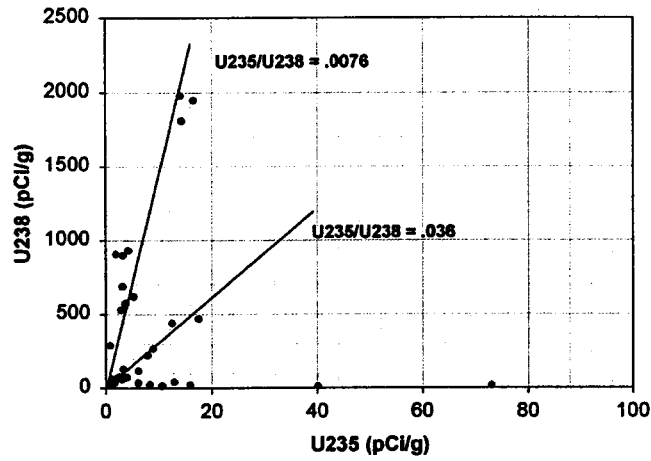


Figure 3. Apparent concentration ratios.

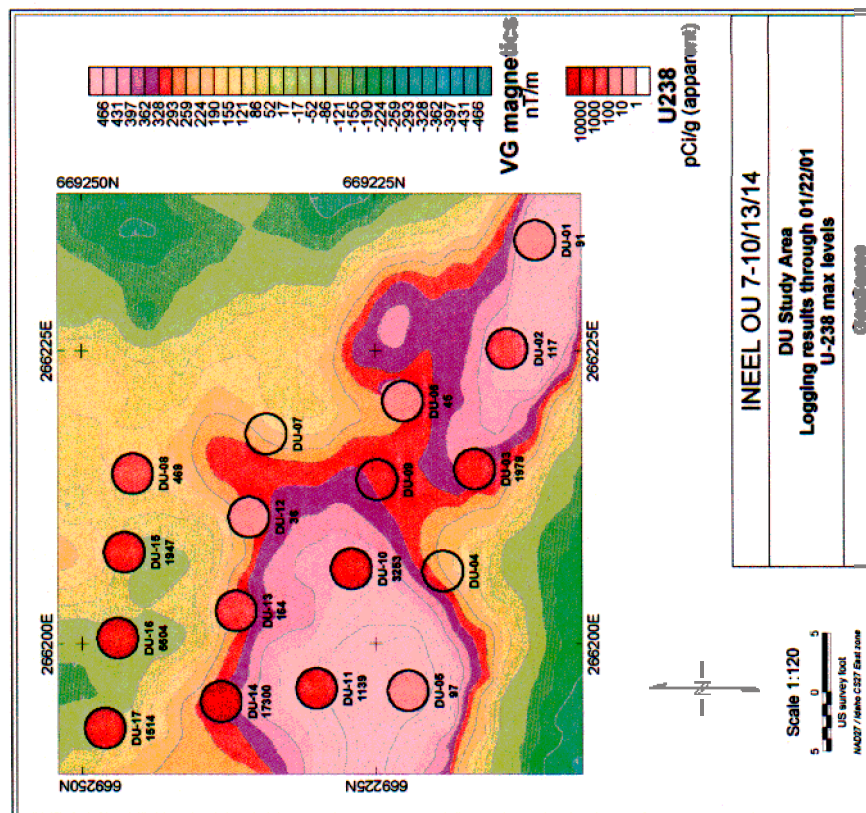
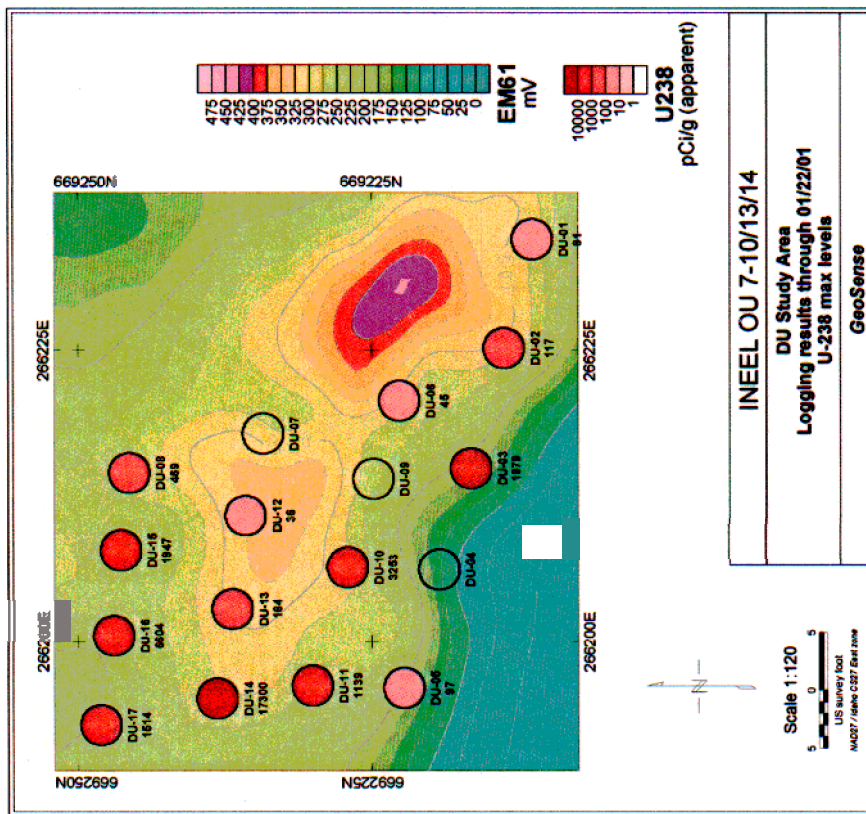


Figure 4. Apparent U-238 concentrations compared with surface geophysics.

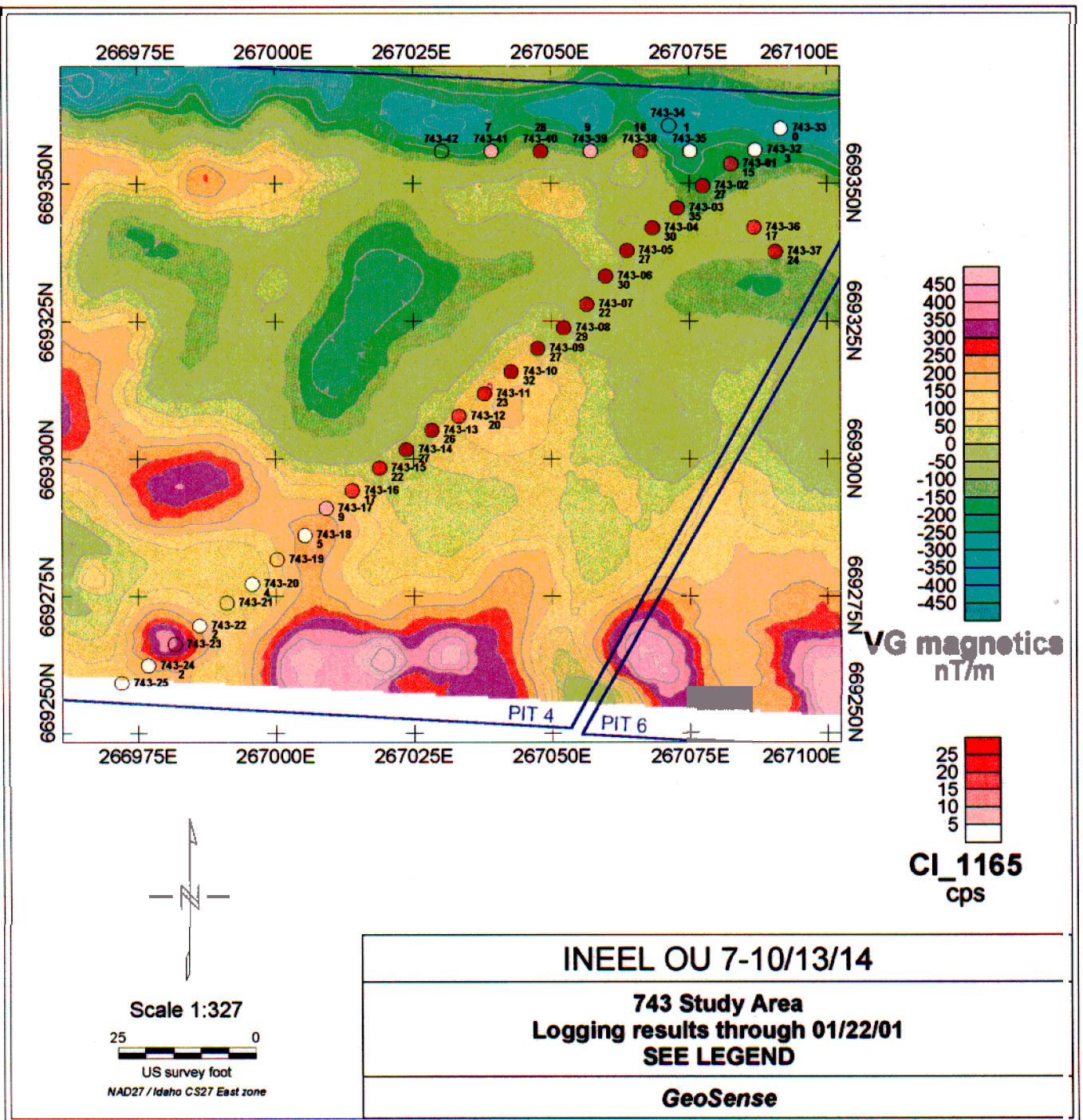


Figure 5. CI_1165 keV logging results compared with surface geophysics.

APPENDIX A

J. Mandler notes on evaluation of DU and 741 Study Area subcontractor data

Observations and Comments
Logging Data for Pits 4 & 10 DU and 741 Study Areas
J.W. Mandler
Updated 12/05/00

DU-1

Elevated levels of ^{238}U (up to 90 pCi/g) were seen by GTS Duratek in the 4.5-10.5 ft region. ^{235}U was seen at 9.5 and 10 ft, at concentrations of 1.3 and 1.2 pCi/g, respectively.

$^{235}\text{U}/^{238}\text{U}$ activity ratios (at the 9.5-10 ft level, the only locations where ^{235}U was detected) ranged from 0.03 to 0.05. Since the $^{235}\text{U}/^{238}\text{U}$ activity ratio for natural uranium is 0.047, the measured activity ratios indicate that the uranium is either natural or enriched, but located far from the probe (i.e., is highly attenuated).

^{232}Th levels are depressed (by up to slightly more than a factor of 2) in the 6.5-10 ft region, essentially the region where the elevated levels of ^{238}U were seen.

^{40}K levels are depressed (up to more than a factor of 2 below normal values) in the 6.5-10 ft region, essentially the region where the elevated levels of ^{238}U were seen.

The x2 depression of the ^{232}Th and ^{40}K concentrations in the 6.5-10 ft region indicates the presence of waste, which displaced some of the soil.

GTS Duratek found no ^{241}Am , ^{239}Pu , ^{233}Pa .

DU-2

Elevated levels of ^{238}U (up to 117 pCi/g at the 7.5 ft level) were seen in the 5.5-10 ft level and at the 4 ft level. ^{235}U was seen at 7.5 and 8 ft, concentrations of 6.2 and 3.9 pCi/g, respectively.

$^{235}\text{U}/^{238}\text{U}$ ratios ranged from 0.02 to 0.05. This indicates that the uranium is either natural or enriched, but located far from the probe (i.e., is highly attenuated).

^{239}Pu was seen in the 7-8 ft region (peaking at slightly over 30 nCi/g in the 7-7.5 ft region). If GTS Duratek used only the 414 keV gamma ray to measure ^{239}Pu , then the reported ^{239}Pu concentrations will be biased high by about 10-15% due to the 416 keV gamma ray from ^{233}Pa .

GTS Duratek found ^{241}Am at the 0.5 ft level, in the 2.5-3 ft region (7-10 nCi/g). At the 4 ft level (10 nCi/g), in the 6-9 ft region (9-179 nCi/g), and at the 10 ft level (11 nCi/g). It peaked in the 7-8 ft region (reaching a peak of 179 nCi/g at the 7.5 ft level).

At the 7.5 ft level, the $^{241}\text{Am}/^{237}\text{Np}$ ratio was 3.6E04. This is lower by about a factor of 3 than it would be if all the ^{237}Np came from the decay of ^{241}Am and lower by almost a factor of 5 than it would be if all the ^{237}Np came from the decay of ^{241}Pu through ^{241}Am .

Using the GTS Duratek reported ^{239}Pu concentrations, the $^{239}\text{Pu}/^{241}\text{Am}$ ratios were 0.37, 0.18, and 0.12 at the 7, 7.5, and 8 ft levels, respectively. These values are much lower than the value of 6.7 which is what would be expected from 30-year-old weapons-grade material in which all the ^{241}Am came from the decay of ^{241}Pu . The ratios indicate that 94-98% of the ^{241}Am that is seen is a source of separated ^{241}Am and not from the decay of ^{241}Pu . If our corrected ^{239}Pu concentrations are used, then the $^{239}\text{Pu}/^{241}\text{Am}$ ratios would

be slightly lower and the fraction of the ^{241}Am coming from the decay of ^{241}Pu correspondingly lower also.

^{233}Pa was seen in the 7-8 ft region (peaking at 5 pCi/g at 7.5 ft level). Its activity tracked the ^{239}Pu activity, so they are probably associated.

Using the GTS Duratek reported ^{239}Pu concentrations, the $^{239}\text{Pu}/^{233}\text{Pa}$ ratios were 1.0E04, 6.6E03, and 4.8E03 at the 7, 7.5, and 8 ft levels. These ratios are much smaller than the ratio expected (i.e., 1.107E06) from 30-year-old weapons-grade plutonium. The corresponding $^{241}\text{Am}/^{233}\text{Pa}$ ratios were 2.8E04, 3.6E04, and 3.8E04. These ratios are lower than the ratio expected (i.e., 1.00E05) from 30 year-old ^{241}Am . The ratios indicate that less than 1% of the ^{237}Np came from the decay of ^{241}Pu and that 62-72% of the ^{237}Np did not come from the decay of ^{241}Am .

The conclusion is that there is both added ^{241}Am and added ^{237}Np . The ratios indicate that less than 1% of the ^{237}Np came from the decay of ^{241}Pu and that only 28-38% came from the decay of ^{241}Am . Therefore, most of the ^{237}Np (i.e., 60-70%) is from additional, separated ^{237}Np .

^{40}K seemed about normal at all levels.

^{232}Th activity was elevated (by up to about a factor of 6) in the 6.5-9 ft region (peaking at 8 pCi/g at 7.5 ft level). The gamma rays upon which this identification is based are the 583 keV and 2614 keV gamma rays from the decay of ^{208}Tl (a progeny of ^{232}Th). Review of the spectrum obtained at 7.5 ft (the level where the reported ^{232}Th concentration is maximum) indicated no 911 keV or 969 keV gamma rays. These gamma rays (from the decay of ^{228}Ac) should be present if the actual parent radionuclide is ^{232}Th . A review of spectra obtained from levels where the reported ^{232}Th concentration is normal (i.e., is due to natural ^{232}Th in the soil) indicates a normal intensity 911 keV and 969 keV gamma-ray peaks. The absence of the 911 keV and 969 keV gamma rays indicates that the parent radionuclide of most of the ^{208}Tl actually is ^{228}Th rather than ^{232}Th . The conclusion is that there is a source of separated ^{228}Th in the waste. Since ^{228}Th has a half-life of 1.9131 years, there had to be a relatively large amount of ^{228}Th in the waste when it was buried. After 30 years, the fraction of ^{228}Th left would be 1.8E-05. Therefore, 8 pCi/g today would have been 445 nCi 30 years ago.

Review of the spectrum obtained at the 7.5 ft level, where the reported ^{241}Am concentration peaked, indicated a 583 keV peak, probably from the (alpha,n) reaction on fluorine by alphas from ^{241}Am , and a very small 1274 keV peak, probably from the (alpha,p) reaction of fluorine by alphas from ^{241}Am .

DU-3

Elevated levels (up to 1979 and 1810 pCi/g at 8.5 and 9 ft, respectively) of ^{238}U were seen in the 5.5-12.5 ft region. ^{235}U was seen in the 7-9.5 ft region (peaking at 14 pCi/g at 8.5-9 ft).

$^{235}\text{U}/^{238}\text{U}$ activity ratios ranged from 0.003 to 0.0085. This indicates that the ^{238}U is either depleted or is located far from the probe (i.e., is highly attenuated).

^{232}Th levels are depressed (by up to slightly more than a factor of 2) in the 5.5-9 ft region, essentially the same region where the ^{238}U level is elevated.

^{40}K levels were elevated (up to more than a factor of 2 above normal levels) in the 5.5-6.5 ft region.

Neither ^{239}Pu nor ^{241}Am nor ^{237}Np were detected by GTS Duratek.

DU-4

GTS Duratek detected ^{241}Am at the 4 ft level, in the 5-6 ft region, in the 7-9 ft region, and at the 10 ft level. The ^{241}Am concentration peaked in the 6-8 ft region (reaching a peak value of 128 nCi/g at the 7.5 ft level).

No ^{238}U (other than natural uranium), ^{235}U , ^{239}Pu , or ^{233}Pa were detected by GTS Duratek.

^{232}Th and ^{40}K levels were normal at all levels.

Review of the spectrum obtained at the 7.5 ft level, the level where the reported ^{241}Am concentration peaked, indicated a small 584 keV peak (probably from the (alpha, n) reaction on fluorine) but no 1274 keV peak. There was a hint of a 352 keV peak, possibly from the (alpha,n) reaction on ^{18}O .

DU-5

Elevated levels of ^{238}U were seen in the 6-8 ft region (peaking at 97 pCi/g at the 7.5 ft level). ^{235}U was not seen, indicating that the uranium was either depleted or was located far from the probe (i.e., was highly attenuated).

^{232}Th activity was depressed (up to about a factor of 2) in the 6.5-8 ft region.

^{40}K activity was slightly depressed (less than 50%) in the 6.5-7.5 ft region.

No ^{235}U , ^{239}Pu , ^{241}Am , or ^{233}Pa were seen by GTS Duratek.

DU-6

Elevated levels of ^{238}U were seen at the 1.13, 3.45, and 16 ft levels and in the 6.5-10 ft region. Peak concentrations occurred in the 7.5-9.5 ft region (peaking at 40 and 45 pCi/g at 8.5 and 7.5 ft levels, respectively). No ^{235}U was detected, indicating that the uranium was either depleted or was natural (with its daughters removed) but located far from the probe (i.e., was highly attenuated).

662 keV gamma ray was detected by GTS Duratek at 8.5 ft level and in the 3-4 ft and 6-7 ft regions. My analysis indicates a definite 662 keV peak only at the 3.5 ft level. At the 3.5 ft level there is also a slight hint of a 722 keV peak, indicating that the 662 keV gamma ray is probably from ^{241}Am . It is stretching to detect a 662 keV peak at the other locations.

^{232}Th activity showed a depression (up to more than a factor of 2) in the 6-10.5 ft region.

^{40}K activity exhibited elevated levels in the 8.5-9.5 ft region (up to about a factor of almost 2) and depressed levels (up to in the 6.5-7.5 ft region).

No ^{235}U , ^{239}Pu , ^{241}Am , nor ^{233}Pa were seen by GTS Duratek.

DU-7

^{239}Pu was seen by GTS Duratek in the 7.5-8.5 ft region, at levels from 37 to 64 nCi/g.

^{241}Am was seen by GTS Duratek at the 4.5 ft level, 6 ft level, 7-8.5 ft region, and 10.5 ft level. The concentration in the 7-8.5 ft region varied from 20 to 41 nCi/g.

$^{239}\text{Pu}/^{241}\text{Am}$ ratios were 1.3, 1.8, and 1.9 at the 7.5, 8, and 8.5 ft levels, respectively. These ratios are lower than the value of 6.7 which is what is expected from 30-year-old weapons-grade plutonium with no added ^{241}Am . The ratios indicate that 72-81% of the ^{241}Am did not come from the decay of ^{241}Pu but rather from an additional source of separated ^{241}Am .

^{232}Th concentrations exhibited an increase (about a factor of 2-3) in the 7-8.5 ft region. Review of the spectra indicated that the 911 keV and 969 keV gamma-ray peaks increased proportionately with the 583 keV and 2614 keV peaks. Therefore, in this case, the ^{232}Th concentration actually exhibited an increase (as opposed to no increase in the ^{232}Th but an increase in the ^{228}Th as seen in DU-2).

No ^{238}U (other than natural U), ^{235}U , or ^{233}Pa were seen by GTS Duratek.

Review of the spectrum obtained at the 7.5 ft level, the level where the reported ^{241}Am concentration peaked, indicated a small 583 keV peak (possibly from the (alpha,n) reaction on fluorine) and a very small 352 keV peak (possibly due to the (alpha,n) reaction on ^{18}O).

DU-8

^{239}Pu found at depths between 12 and 16 ft. Peaked at 14.5-15 ft (4944 nCi/g at 14.5 ft level). If GTS Duratek used only the 414 keV gamma ray as a measure for ^{239}Pu , then the reported ^{239}Pu concentrations are biased high due to interference from the 416 keV gamma ray from ^{233}Pa . If this is the case, then 48%, 71%, 86%, 80%, 60%, and essentially all of the ^{239}Pu reported at 13.5 ft, 14 ft, 14.5 ft, 15 ft, 15.5 ft, and 16 ft, respectively, is due to ^{233}Pa . Hence the ^{239}Pu concentrations really are 24 nCi/g, 175 nCi/g, 692 nCi/g, 357 nCi/g, 50 nCi/g, and below LLD at 13.5 ft, 14 ft, 14.4 ft, 15 ft, 15.5 ft, and 16 ft, respectively.

^{233}Pa (i.e., ^{237}Np) found at depths between 13 and 16 ft. It peaked at 14.5-15 ft (4881 pCi/g at 14.5 ft level). It seems to be associated with the ^{239}Pu , its activity tracked the ^{239}Pu activity. Using GTS Duratek's reported ^{239}Pu concentrations, $^{239}\text{Pu}/^{237}\text{Np}$ activity ratios were in the 1.0E03-1.6E03 range for depths of 13.5-15.5 ft. This ratio is much lower (by orders of magnitude) than the ratio (1.107E06) that would be expected if the ^{237}Np resulted from the decay of ^{241}Pu . The ratios indicate that 0.3% of the ^{237}Np came from the decay of ^{241}Pu . However, using our corrected ^{239}Pu concentrations, $^{239}\text{Pu}/^{237}\text{Np}$ activity ratios would be in the 1.4E02-8.3E02 range. These ratios indicate that less than 0.1% of the ^{237}Np came from the decay of ^{241}Pu .

GTS Duratek did not observe any ^{241}Am in the spectra. This is strange because 30-year-old weapons-grade plutonium should have a $^{239}\text{Pu}/^{241}\text{Am}$ ratio of about 6.7. Hence, ^{241}Am concentrations from 1.3 to 738 nCi/g should have been present. Since I would expect the GTS system to have a ^{241}Am detection limit of about 5 nCi/g, we should have seen ^{241}Am at 5 of the 8 locations where ^{239}Pu was seen.

I reviewed the spectrum taken where the indicated ^{239}Pu and ^{237}Np concentrations were a maximum. I performed a quick review of the spectrum taken at the 14.5 ft level and found no 208 keV gamma. The 335 keV line would be masked by the intense 341 keV gamma from ^{233}Pa . I saw a small 662 keV peak and a small 722 keV peak. Therefore, some ^{241}Am is actually present. The 369 keV gamma would be masked by the 375 keV gamma from ^{239}Pu . Nevertheless, the amount of ^{241}Am present is small compared to the amount of ^{233}Pa present. Much more ^{241}Am would be expected to be seen if the ^{237}Np detected had resulted from the decay of ^{241}Am . Therefore, there is a source of separated ^{237}Np .

Elevated levels of ^{232}Th were found at depths of 13.5-15.5 ft (peaked at 14-15 ft, concentration at 14.5 ft was 7.85 pCi/g) and at 7.5-9 ft. Normal soil above and below the waste was in the 1.1-1.5 pCi/g range. Depressed levels (down to about 0.6-0.7 pCi/g) were found in the 12-12.5 ft level and the 6-6.5 ft level.

Would we expect to have any separated ^{232}Th in the Rocky Flats waste? A review of the spectra indicated that the reported ^{232}Th increase in both the 13.5-15.5 ft region and 7.5-9 ft region was due to ^{228}Th (conclusion based on lack of increase of 911 keV and 969 keV peak intensities as the 583 keV and 2614 keV peak intensities increased).

GTS Duratek reported seeing ^{137}Cs in the 5.5-6.5 ft region, in the 7.5-8.5 ft region, at the 11 ft level, and in the 13-15.5 ft region. As mentioned above, the 662 keV peak at the 14.5 ft level is due to ^{241}Am . I reviewed the spectrum obtained at the 11 ft level and found no evidence at all of a peak at 662 keV. I saw a 662 keV and a 722 keV gamma in the spectrum taken at the 156-ft level. Therefore, I suspect that the other reported values for ^{137}Cs are either due to ^{241}Am or are not really present (as is the case for the 11 ft level).

Elevated levels of ^{238}U were found at depths of 11-15.5 ft and 7.5-8.5 ft. The largest peak (469 pCi/g) was found at 12-12.5 ft, and smaller peaks were found at 14.5-15 ft (92 pCi/g) and 7.5 ft (45 pCi/g). ^{235}U was detected only at the 12-13 ft level (peaking at 17.5 pCi/g at 12.5 ft).

The $^{235}\text{U}/^{238}\text{U}$ activity ratio at the 12-12.5 ft depth was 0.03. This might indicate natural U ($^{235}\text{U}/^{238}\text{U}$ activity ratio of natural U is 0.046) or enriched U at a distance (i.e., highly attenuated). ^{235}U was not seen at other depths, although it should have been seen if it was natural or enriched U, unless it was located far from the probe (i.e., highly attenuated).

Elevated levels of natural U (determined from the ^{214}Pb and ^{214}Bi activities) were found at the 7.5-8.5 ft levels. Since the natural U daughters were not seen above normal levels elsewhere where elevated levels of ^{238}U were seen, the ^{238}U probably in those regions is either enriched U or natural U which had been separated from its daughters.

^{40}K was depressed (by about a factor of 2) in the 12-13.5 ft region and in the 7.5-8.5 ft region. It was elevated. It was elevated in the 5-7 ft region, peaking (almost a factor of 3 above normal levels) at 6.5 ft depth.

741-2

GTS Duratek detected ^{239}Pu in the 9-13 ft region (peaking at approximately 2000 nCi/g at the 10 and 10.5 ft levels). If GTS Duratek used only the 414 keV gamma ray to measure ^{239}Pu , then the reported ^{239}Pu concentrations would be biased high by about 5-12% in the 9-10.5 ft region and about 32-44% in the 11-12.5 ft region. The true ^{239}Pu concentrations would be about 66 nCi/g, 746 nCi/g, 1815 nCi/g, 1861 nCi/g, 928 nCi/g, 916 nCi/g, 294 nCi/g, and 47 nCi/g at the 9, 9.5, 10, 10.5, 11, 11.5, 12, and 12.5 ft levels, respectively.

^{233}Pa was seen by GTS Duratek in the 9-17 ft region. Values peaked at the 11 and 11.5 ft levels at 378 and 422 pCi/g, respectively. It peaked at a level about 1 ft below where the ^{239}Pu peaked.

^{241}Am was seen by GTS Duratek at the 0 ft level, at the 1.5 ft level, at the 5.63 ft level, and in the 8-17.51 ft region. It peaked at the 11 and 11.5 ft levels at values of 12,422 and 13,106 nCi/g, respectively.

Based on the GTS Duratek reported ^{239}Pu concentrations, the $^{239}\text{Pu}/^{241}\text{Am}$ ratios ranged from 0.23 to 0.32 in the 9-10.5 ft region, dropped to about 0.1 at 11 and 11.5 ft and then to 0.072, 0.042, and 0.034 at 12, 12.5, and 13 ft, respectively. These ratios are well below the value of 6.7 that is expected from 30-year-old weapons-grade plutonium with no added ^{241}Am . The ratios indicate that in the 9-10.5 ft region, only 3-5% of the ^{241}Am came from the decay of ^{241}Pu . In the other regions, the percentage was about 1%. Therefore, almost all of the ^{241}Am seen is due to additional, separated ^{241}Am . If our corrected ^{239}Pu

concentrations are used, then the $^{239}\text{Pu}/^{241}\text{Am}$ ratios would be lower and the fraction of the ^{241}Am coming from the decay of ^{241}Pu correspondingly lower also.

Based on the GTS Duratek reported ^{239}Pu concentrations, the $^{239}\text{Pu}/^{237}\text{Np}$ ratios decreased with depth throughout the 9-13 ft region, ranging from $1.5\text{E}04$ to $1.8\text{E}03$. These ratios are much lower than the ratio expected (i.e., $1.107\text{E}06$) from 30-year-old weapons-grade plutonium. These ratios indicate that the fraction of the ^{237}Np that came from the decay of ^{241}Pu decreased in this region from about 1.4% to 0.2%. If our corrected ^{239}Pu concentrations are used, then the $^{239}\text{Pu}/^{237}\text{Np}$ ratios would be lower and the fraction of the ^{237}Np due to the decay of ^{241}Pu correspondingly lower also.

The $^{241}\text{Am}/^{237}\text{Np}$ ratio was fairly constant in the 9.5-12 ft region at a value of about $3\text{E}04$. This is about a factor of 5 higher than the ratio would be if all the ^{237}Np came from the decay of ^{241}Pu through ^{241}Am . The ratio was higher ($4\text{E}04$ to $6\text{E}04$) at most other locations, but still well below what it would be if all the ^{237}Np came from the decay of ^{241}Pu through ^{241}Am .

$^{241}\text{Am}/^{237}\text{Np}$ ratios were $5.97\text{E}04$ at 9 ft, $3.11\text{E}04$ - $3.41\text{E}04$ in the 9.5-12 ft region, $4.16\text{E}04$ at 12.5 ft, $5.61\text{E}04$ at 13 ft, $6.39\text{E}04$ at 13.5 ft, $5.89\text{E}04$ at 14 ft, $3.68\text{E}04$ at 14.5 ft, $2.64\text{E}04$ at 15 ft, $4.41\text{E}04$ at 15.5 ft, $5.89\text{E}04$ at 16 ft, $3.41\text{E}04$ at 16.5 ft, and $3.27\text{E}04$ at 17 ft. These are lower than the expected ratio of $1.005\text{E}05$ that would be expected from 30-year-old ^{241}Am . These ratios indicate that about 41-69% of the ^{237}Np did not come from the decay of ^{241}Am , but is an additional source of separated ^{237}Np .

A 1274 keV gamma was seen by GTS Duratek in the 8.5-14.5 ft region (peaking at a value of 14.0 and 14.6 cps at the 10 and 10.5 ft levels, respectively) and at the 16 ft level. This gamma ray is due to the (alpha,p) reaction on fluorine. Also seen in the 8-15 ft region (peaking at a value of 5.6 and 5.2 cps at the 10 and 10.5 ft levels, respectively) was the 2223 keV gamma ray from the (n,gamma) reaction on hydrogen. Both these gamma rays indicate a presence of neutrons, primarily from ^{241}Am . Both these gamma rays had peak intensities about 1 ft above where the ^{241}Am intensity peaked.

Review of some of the spectra taken from the 8.5-14.5 ft region indicated the presence of a 583 keV peak from the (alpha,n) reaction on fluorine.

^{232}Th exhibited enhanced concentrations in the 8.5-17 ft region, peaking at 55 and 58 pCi/g at the 11.5 and 12 ft levels, respectively (about a factor of almost 40 above the concentration seen in normal INEEL soil). Review of the spectra indicates that the reported enhanced concentrations of ^{232}Th are actually due to ^{228}Th .

GTS Duratek was unable to detect natural uranium in the 9.5-12 ft region, probably due to the high levels of ^{241}Am seen in that region.

^{40}K activity exhibited a depression (by up to about a factor of 2) in the 10.5-11.5 ft region.

Neither ^{238}U (other than natural uranium based on ^{214}Bi and ^{214}Pb daughters) nor ^{235}U was reported by GTS Duratek.

741-3

^{238}U was detected in the 17-18.68 ft region (at 21-30 pCi/g) and sporadically at other locations. The presence of ^{235}U was not reported.

GTS Duratek saw ^{239}Pu in the 8.5-12.5 ft region, at the 14 ft level, and in the 17-18.68 ft region. The concentration peaked twice in the 9-10.5 ft region, at values ranging from 672 nCi/g to 782 nCi/g between 9 and 10.5 ft and at values from 488 to 508 nCi/g between 11.5 and 12 ft. Another peak was seen in the 18-18.68 ft region, reaching values of 133 and 172 nCi/g at the 18.5 and 18.68 ft levels, respectively. Since 18.68 ft is as deep as was logged, the depth to which the ^{239}Pu extends is unknown as is the location and concentration of the peak.

If GTS Duratek used only the 414 keV gamma ray to measure ^{239}Pu , then the reported concentrations would be significantly biased high (about 16-32%) for the 8.5-12.5 ft region. The values reported for the 18-18.68 ft region would be biased high by 2% or less. The corrected ^{239}Pu concentrations would be about 105 nCi/g, 594 nCi/g, 541 nCi/g, 599 nCi/g, 525 nCi/g, 319 nCi/g, 406 nCi/g, 356 nCi/g, and 179 nCi/g at the 8.5 ft, 9 ft, 9.5 ft, 10 ft, 10.5 ft, 11 ft, 11.5 ft, 12 ft, and 12.5 ft levels, respectively.

^{241}Am was detected by GTS Duratek in the 0.5-1 ft region; at the 2, 4, and 6 ft levels, in the 7.5-14.5 ft region; and at the 15, 17, and 18.68 ft levels. Two peaks were observed in the 7.5-14.5 ft region (7938 nCi/g at 9.5 ft and 4822 nCi/g at 12 ft). These locations are approximately where the ^{239}Pu exhibited its peak concentrations.

Based on the GTS Duratek reported ^{239}Pu concentrations, the $^{239}\text{Pu}/^{241}\text{Am}$ ratios were on the order of 0.1 at all locations except for the 17 and 18.68 ft levels, where they were 1.3 and 8.5, respectively. This indicates that all the ^{241}Am seen except at the 18.68 ft level is due to excess ^{241}Am , but at the 18.68 ft level it is due to ^{241}Am from the decay of ^{241}Pu .

^{233}Pa was seen in the 8.5-14 ft and 18-18.68 ft regions. As with ^{239}Pu and ^{241}Am , two peaks were seen (244 pCi/g at 9.5 ft and 127 pCi/g at 12 ft). These locations are approximately where the other radionuclides exhibited peak concentrations.

The $^{241}\text{Am}/^{233}\text{Pa}$ ratio was about 3.5E04 in the 9-12.5 ft region but higher (about 4.5E04 to 8.7E04) in the 13-14 ft region. 3.5E04 is about a factor of 3 lower than the expected ratio if all the ^{237}Np came from the decay of ^{241}Am . The ratios are lower than the ratio (1.005E05) expected from 30-year-old weapons-grade plutonium. These ratios indicate that about 13-65% of the ^{237}Np came from the decay of ^{241}Am .

Based on the GTS Duratek reported ^{239}Pu concentrations, the $^{239}\text{Pu}/^{237}\text{Np}$ ratios were in the 3.3E03-5.5E03 in the 8.5-12.5 ft region, 7.2E02 at the 14 ft level, and 6.6E04-1.3E05 in the 18-18.68 ft region. These ratios are much lower than the ratio expected (1.107E06) from 30-year-old weapons-grade plutonium. These ratios indicate that in the 8.5-12.5 ft region and at the 14 ft level, less than 0.5% of the observed ^{237}Np came from the decay of ^{241}Pu . For the 18-18.68 ft level, 60-100% of the ^{237}Np came from the decay of ^{239}Pu .

^{40}K concentration showed slightly higher values at lower depths and a slight deficiency in the 13-13.5 ft region.

^{232}Th exhibited elevated concentrations in the 8.5-14 ft region, peaking at 10 pCi/g at 11.5 and 12 ft. Review of the spectra indicates that these reported elevated concentrations are actually due to ^{228}Th .

Natural uranium showed a decrease of about a factor of 2-3 at levels in the 8-11.5 ft region where values were obtained (values were not obtained at every level).

Hydrogen capture gamma rays were seen in the 7-15 ft region, peaking at slightly over 5 cps at 9.5-10 ft and at 11.5 ft. 1274 keV gamma rays from the (alpha,p) reaction on fluorine were seen in the 7-14.5 ft region, peaking at about 8 cps at the 9.5 ft level and at about 16 cps at 11.5-12 ft. 1778 keV gamma rays (probably from the (n,p) reaction on silicon) were seen in the 7.5-12.5 ft region, peaking at about 0.7 cps at the 10.5 ft level. All of these reaction gamma rays indicate the presence of a neutron flux (both fast and thermal), which is mainly due to the neutrons from (alpha,n) reactions caused by the alphas from ^{241}Am .

Review of spectra obtained from the 9-12 ft region indicated the presence of a fairly large 1274 keV peak and a small 583 keV peak, both from alpha-induced reactions on fluorine.

741-4

^{239}Pu was seen by GTS Duratek in the 8.5-13 ft region (peaking at 1065 nCi/g at 9.5 ft and 478 at 12 ft). If GTS Duratek used only the 414 keV gamma ray to measure ^{239}Pu , then the reported values are biased high (by 5-19%) due to interference from the 416 keV gamma ray from ^{233}Pa . The corrected ^{239}Pu concentrations are 13.5 nCi/g, 314 nCi/g, 894 nCi/g, 735 nCi/g, 657 nCi/g, 187 nCi/g, 257 nCi/g, 429 nCi/g, 136 nCi/g for the 8.5, 9, 9.5, 10, 10.5, 11, 11.5, 12, and 12.5 ft levels, respectively.

^{241}Am was seen by GTS Duratek in the 8-14.5 ft region, 17.7-18 ft region, 20 ft level, and the 22.5 ft level. The 17.7-18 ft region, 20 ft level, and the 22.5 ft level. The errors are large for the results in all but the 8.5-14 ft region. Two peaks in concentration were seen, 5509 nCi/g at 9.5 ft and about 2300 at 11.5-12 ft.

$^{239}\text{Pu}/^{241}\text{Am}$ ratios were generally in the 0.1 to 0.2 range. This is much lower than the expected ratio (6.7) for 30-year-old weapons-grade plutonium. The ratios indicate that 97-95.5% of the ^{241}Am did not come from the decay of ^{241}Pu but from an additional, separated source of ^{241}Am .

^{233}Pa was detected by GTS Duratek in the 8.5-12.5 ft region (peaking at 172 pCi/g at 9.5 ft).

$^{241}\text{Am}/^{233}\text{Pa}$ ratio ranged from 3.2E04 to 7.0E04, which is much lower than the value of 1.005E05 which would be expected if all the ^{237}Np came from the decay of ^{241}Am . These ratios indicate that 30-68% of the ^{237}Np did not come from the decay of ^{241}Am , but from an additional, separated source of ^{237}Np .

Using the GTS Duratek reported ^{239}Pu concentrations, the $^{239}\text{Pu}/^{237}\text{Np}$ ratios were 3.0E03 at the 8.5 ft level, 5.7E03-8.6E03 in the 9-12 ft region, and 1.61E04 at the 12.5 ft level. These ratios are much lower than the ratio (1.107E06) expected from 30-year-old weapons-grade plutonium. This indicates that less than 1% of the ^{237}Np in the 8.5-12 ft region and about 1.5% of the ^{237}Np at the 12.5 ft level is due to the decay of ^{241}Pu .

GTS Duratek reported ^{137}Cs in the 6-6.5 ft (very low concentrations, probably not statistically significant) and 13-20 ft regions (peaking at 112 pCi/g at 14.5 ft and 140 pCi/g at 16-16.5 ft). I checked the spectrum taken at 14.5 ft, and the peak is definitely due to ^{137}Cs . It is a very large peak, and no hint of a 722 keV peak is seen.

Hydrogen capture gamma rays were seen in the 8-15 ft region (peaking at 2.5-2.7 cps at 9.5-10.5 ft). 1274 keV gamma rays (from the (alpha,p) reaction on fluorine) were seen in the 8-14.5 ft region (peaking at 10.4 cps at 9.5 ft, approximately where the hydrogen capture gamma rays peaked). The presence of these gamma rays indicates a neutron flux (both thermal and fast), probably due to the ^{241}Am .

Review of the spectra obtained from the 9-12 ft region indicated the presence of a 1274 keV and a small 583 keV peak, both from alpha-induced reactions on fluorine.

^{40}K exhibited a slight depression in the 10.5-11.5 ft region.

^{232}Th exhibited an enhanced concentration in the 9-13.5 ft region, peaking at 11 pCi/g at 10.5-11 ft. Review of the spectra indicates that these reported enhanced concentrations are actually due to ^{228}Th .

Neither ^{238}U (other than natural uranium detected from its ^{214}Bi and ^{214}Pb daughters) nor ^{235}U was reported by GTS Duratek.

741-6

^{238}U was seen in the 3.5-4 ft region (at levels of 3-4 pCi/g), in the 10.5-16.5 ft region (at levels of 11.8-681 pCi/g, peaking at 13.5-14.5 ft), and at the 17.44 ft level (at 5 pCi/g). ^{235}U was detected in the 14.5-17.44 ft region (peaking at 84 pCi/g at 15.5 ft).

The $^{235}\text{U}/^{238}\text{U}$ activity ratio was 0.0043 at 14.5 ft, 0.097 at 15 ft, 0.98 at 15.5 ft, 2.17 at 16 ft, 1.43 at 16.5 ft, and 1.44 at 17.44 ft. This indicated the presence of enriched- or highly enriched uranium at about the 16-ft level and the presence of depleted uranium in the 10.5-14.5 ft region.

Review of the spectra indicated that the 144 keV gamma ray from the decay of ^{235}U is seen in the spectra obtained at the 15.5 and 16-ft levels. The intensity of this gamma ray is highest at the 15.5 ft level, and the 186 keV/144 keV peak intensity ratios are similar to what would be expected for ^{235}U measured through the $\frac{1}{2}$ "-thick probe wall by the GTS Duratek detector. This indicates that at this level the ^{235}U is relatively close to the probe, i.e., there is essentially no intervening soil between the ^{235}U and the probe.

GTS Duratek reported ^{239}Pu at levels of 15.7-1504 nCi/g in the 9.5-12 ft region (peaking at the 10.5 ft level). Corrections due to interference from the 416 keV ^{233}Pa gamma ray (if GTS Duratek used only the 414 keV line for determining ^{239}Pu) would be on the order of 4% or less.

^{241}Am was seen in the 6.5-7 ft region (at levels of about 7-15 nCi/g) and in the 9-12.5 ft region (peaking at the 10.5 ft level at 2386 nCi/g).

^{233}Pa was seen in the 10-11.5 ft region (peaking at the 10.5 ft level at 72 pCi/g).

$^{239}\text{Pu}/^{237}\text{Np}$ ratios ranged from 1.73E04 to 2.51E04. These ratios are much lower than the ratio expected (1.107E06) from 30-year-old weapons-grade plutonium. The ratios indicate that only about 1-2% of the ^{237}Np is due to the decay of ^{241}Pu .

$^{241}\text{Am}/^{237}\text{Np}$ ratios were 5.14E04, 3.31E04, 3.85E04, and 9.23E04 at the 10, 10.5, 11, and 11.5 ft levels, respectively. Except for the 11.5 ft level, these ratios are lower than the expected ratio (1.005E5) for 30-year-old ^{241}Am . The ratios in the 10-11 ft region indicate that about 49-67% of the ^{237}Np is not due to the decay of ^{241}Am , but from an additional source of separated ^{237}Np .

$^{239}\text{Pu}/^{241}\text{Am}$ ratios are 0.29, 0.49, 0.63, 0.53, 0.19, 1.07 at the 9.5, 10, 10.5, 11, 11.5, and 12 ft levels. These ratios are much lower than the ratio expected (6.7) for 30-year-old weapons-grade plutonium. The ratios indicate that 84-97% of the ^{241}Am is not from the decay of ^{241}Pu but from an additional source of separated ^{241}Am .

Review of the spectrum obtained from the 10.5 ft level indicated the presence of small 583 keV and 1274 keV peaks, from alpha-induced reactions on fluorine.

^{40}K behaved approximately normally throughout the 0.5-13.5 ft region (although there was a slight increase in concentration in the 67-7.5 ft region). The ^{40}K concentration began to decrease at 14 ft, dropping to almost $\frac{1}{2}$ its normal value by the time a 17-ft depth was reached.

^{232}Th exhibited an increase in the 9.5-11.5 ft region (peaking at 5.86 pCi/g at 10.5 ft). Review of the spectra indicates that these reported increased concentrations are actually due to ^{228}Th . Its concentration also dropped below normal in the 17-17.44 ft region.

Natural U exhibited a lower-than-normal concentration at 11.5 ft and was not detected in the 10-11 ft region.

741-8

^{239}Pu was detected by GTS Duratek in the 7-16 ft region, peaking at two locations, 8058 nCi/g at 8 ft and 230-240 pCi/g at 12.5-13.5 ft. Corrections due to interference from the 416 keV gamma ray from ^{233}Pa (if GTS Duratek used on the 414 keV gamma ray to measure ^{239}Pu) would be about 6% or less.

^{241}Am was seen at the 4 level, in the 6-13.82 ft region, and in the 15-16 ft region. Peaks of 8874 nCi/g and 174 nCi/g were observed at 8 ft and 12.5 ft, respectively.

^{233}Pa was seen in the 7-13.5 ft region, peaking at 311 pCi/g at 8.5 ft.

^{239}Pu , ^{241}Am , and ^{233}Pa all peaked at 8-8.5 ft. ^{239}Pu peaked again at 12.5-13.5 ft; ^{241}Am and ^{233}Pa peaked at a bit higher level (12.5 ft)

$^{239}\text{Pu}/^{237}\text{Np}$ ratios varied from 1.31E04 to 3.47E04 for the 7-12.5 ft region, rose to 6.18E04 at the 13 ft level, rose to 1.328E05-1.608E05 at 13.5-14.5, and dropped to 3.21E04 at 15.5 ft. These ratios are much lower than the ratio expected (1.107E06) for 30-year-old weapons-grade plutonium. The ratios indicate that in the 13.5-14.5 ft region, 85-88% of the ^{237}Np is not from the decay of ^{241}Pu , at 13 ft 94% of the ^{237}Np is not from the decay of ^{241}Pu , and in the 7-12.5 ft region 97-99% of the ^{237}Np is not from the decay of ^{241}Pu . Most of the ^{237}Np , therefore, is due to an additional source of separated ^{237}Np .

$^{241}\text{Am}/^{237}\text{Np}$ ratios were in the 1.77E04 – 4.83E04 range. These values are lower than the ratio expected (1.005E05) from 30-year-old ^{241}Am . The ratios indicate that about 52-82% of the ^{237}Np is not from the decay of ^{241}Am but from an additional source of separated ^{241}Am .

$^{239}\text{Pu}/^{241}\text{Am}$ ratios varied from 0.27 to 4.27. The ratio was 0.27 at 7 ft, 0.49 – 1.005 in the 7.5-12 ft region, 1.38 at 12.5 ft, 3.49-3.73 in the 13-13.82 ft region (with the exception of an anomalous value of 0.95 at 15 ft), and 1.77 at 16 ft. These values are lower than the expected ratio (6.7) for 30-year-old weapons-grade plutonium. The ratios indicate that the fraction of ^{241}Am not from the decay of ^{241}Pu is about 96% at 7 ft, 85-93% in the 7.5-12 ft region, 79% at 12.5 ft, 44-48% in the 13-13.82 ft region, and 74% at 16 ft.

1274 keV gamma rays from the (alpha,p) reaction on fluorine due to alpha from ^{241}Am were seen in the 6.5-13.5 ft region. Their intensity peaked at 8-8.5 ft (at about 20 cps). Review of the spectra obtained from this region indicated the presence of a 583 keV peak (of lower intensity than the 1274 keV peak), from the (alpha,n) reaction on fluorine.

2223 keV capture gamma rays from (n,gamma) reaction on hydrogen due to neutrons from ^{241}Am reactions were seen in the 6.5-10.5 ft region (peaking at 4.1 cps at the 8 ft level).

^{232}Th exhibited enhanced concentrations in the 6.5-9.5 ft region (peaking at 11-13 pCi/g at 8-8.5 ft). Concentrations above and below this region were normal (i.e., about 1.1-1.4 pCi/g). Review of the spectra indicates that these reported increased concentrations are actually due to ^{228}Th .

The natural uranium concentrations did not exhibit any trend. However, natural uranium was not detected in the 7-9 ft region.

^{40}K concentrations exhibited a depression (less than a factor of 2) in the 12.5-13.82 ft region.

Neither ^{238}U (other than natural uranium detected from its ^{214}Bi and ^{214}Pb daughters) nor ^{235}U was reported by GTS Duratek.

741-9

^{238}U was detected in the 8.91-13.75 ft region at concentrations ranging from about 20 to 267 pCi/g. Two distinct peaks were observed, 267 pCi/g at 10.5 ft and 255 pCi/g at 13 ft.

^{235}U was detected in the 10-13.75 ft region (except at the 12 ft level) at concentrations ranging from 1.5 to 28 pCi/g. Two distinct peaks were observed, 15-18.5 pCi/g at 10.5-11 ft and 29 pCi/g at 13-13.75 ft.

$^{235}\text{U}/^{238}\text{U}$ activity ratios were 0.053, 0.069, 0.076, and 0.015 at 10 ft, 10.5 ft, 11 ft, and 11.5 ft, respectively, and 0.045, 0.11, 0.20, and 0.32 at 12.5 ft, 13 ft, 13.5 ft, and 13.75 ft, respectively. These ratios indicate a source of enriched- or highly enriched uranium at 10.5-11 ft and another source or below 13.75 ft.

A review of the spectra indicated that the 144 keV gamma ray from ^{235}U was seen in the 13-13.75 ft region. The peaks were very small, but on the order of what would be expected for the intensities of the 186 keV peaks seen. Therefore, there is little to no shielding material (e.g., soil) between the ^{235}U and the probe.

No ^{239}Pu , ^{241}Am , or ^{233}Pa were reported.

GTRS Duratek reported seeing ^{137}Cs in the 10-11.5 ft region and in the 13-13.75 ft region. Visual inspection of the spectra indicates the following:

<u>Depth</u>	<u>Comments</u>
10 ft	very small 662 keV peak with no indication of a 722 keV peak (although the 722 keV peak would be expected to be too small to be seen if the 662 keV peak was from ^{241}Am)
10.5 ft	small 662 keV peak with no 722 keV peak (although the 722 keV peak would be expected to be small and very hard to detect if the 662 keV peak was from ^{241}Am)
11 ft	definite 662 keV peak with no 722 keV peak (at least a hint of a 722 keV peak would be expected if the 663 keV peak was from ^{241}Am)
11.5 ft	maybe a very slight hint of a 662 keV peak, but hard to tell
12 ft	no indication whatsoever of a 662 keV peak

12.5 ft no indication of a 662 keV peak

13 ft maybe a very slight hint of a 662 keV peak

13.5 ft very small 662 keV peak with no indication of a 722 keV peak
(although the 722 keV peak would be expected to be too small to
be seen if the 662 keV peak was from ^{224}Am)

13.75 ft very small 662 keV peak with no indication of a 722 keV peak
(although the 722 keV peak would be expected to be too small to
be seen if the 662 keV peak was from ^{241}Am).

My conclusion is that ^{137}Cs may be present at the 11-ft level, but at the other levels, one cannot rule out the 662 keV peak from being from ^{241}Am . Re-logging with longer count times will be required to confirm the presence of ^{137}Cs .

GTS Duratek reported ^{60}Co in the 10-11.5 ft region and in the 13.5-13.75 ft region. Visual inspection of the spectra indicates the following:

<u>Depth</u>	<u>Comment</u>
10 ft	maybe a hint of 1173 and 1332 keV peaks
10.5 ft	hint of an 1173 keV peak but no 1332 keV peak
11 ft	hint of an 1173 keV peak and maybe something at 1332 keV
11.5 ft	hint of an 1173 keV peak and maybe something at 1332 keV
13.5 ft	nothing at 1173 keV but maybe a hint of a peak at 1332 keV
13.75 ft	very small peak at 1173 keV and a hint of a peak at 1332 keV

My conclusion is that maybe a very small amount of ^{60}Co is present, but re-logging using longer count times is required to confirm the presence of ^{60}Co .

^{232}Th exhibited a definite decrease in concentration (up to about a factor of 2 to 3) in the 12-13.75 ft region.

The natural uranium concentration did not exhibit any definite trend.

^{40}K indicated an increased concentration in the 6-10 ft region and a definite decrease in concentration (up to about a factor of 3 to 4) in the 12.5-13.75 ft region.

Appendix B

J. Giles notes on evaluation of DU and 741 Study Area subcontractor data

Recommendations for OU 7-13/14 from Nuclear Data Analysis

John R. Giles

Revised 12/5/2000

An accelerated data analysis was performed on the most recent logging data from the probeholes placed in the DU and 741 Sludge focus areas in support of the OU 7-13/14 project. After review of the data, it was decided that additional information from the existing probeholes should be gathered prior to making a final recommendation for the placement of additional Type A and the Type B probes. The following are the recommendations and justification for the azimuthal logging:

Azimuthal Logging Recommendations

The azimuthal logging in probeholes associated with the DU study area should focus on the relative radial intensity of the 186-keV gamma-ray from the decay of U-235. This low energy gamma-ray will be attenuated by the shielded portion of the azimuthal detector by approximately 80%, while the 1,001-keV gamma-ray from Pa-234m (U-238 daughter) is attenuated by approximately 54%. As a result, the directional capabilities of the azimuthal tool for U-238 are significantly less than for U-235. The azimuthal logs in probeholes associated with the 741 Sludge study area should focus on the directional orientation of all COCs including Pu-239, Am-241 and Np-237 (Pa-233).

DU Study Area

DU-3 Azimuthal logs should be run for the purpose of identifying the directional orientation of the source of U-235 at a depth of 9.0 ft.

DU-8 Azimuthal logs should be run for the purpose of identifying the directional orientation of the source of U-235 at a depth of 12.5 ft.

Probehole DU-8 may also be of interest for use in evaluating 741 Sludge. There were significant quantities of Pu-239 and Pa-233 (Np-237) identified at a depth interval from 13.5 to 16 ft. The maximum Pu-239 concentration reported by GTS is 4,944 nCi/g, and the maximum Pa-233 concentration reported by GTS is 4,881 pCi/g. These maximum concentrations were reported at a depth of 14.5 ft. The Pu-239 and Pa-233 concentrations peak at a different depth than the U-238 and U-235 peak concentrations, suggesting that there may be two different waste types at two distinct locations near this probehole.

741 Sludge Study Area

741-2 Azimuthal logs should be run for the purpose of identifying the directional orientation of Pu-239, Am-241 and Pa-233 at depths of 10.5 and 11.5 ft.

741-3 Azimuthal logs should be run for the purpose of identifying the directional orientation of Pu-239, Am-241 and Pa-233 at a depth of 9.5 ft.

741-6 Azimuthal logs should be run for the purpose of identifying the directional orientation of Pu-239, Am-241 and Pa-233 at a depth of 10.5 ft.

741-8 Azimuthal logs should be run for the purpose of identifying the directional orientation of Pu-239, Am-241 and Pa-233 at depths of 8.0 and 12.5 ft.

Probehole 741-6 may also be of interest for use in evaluating uranium waste. Enriched uranium was identified at a depth interval from 15.0 to 17.44 ft (bottom of probehole).

Probeholes 741-2, 741-3, 741-6, and 741-8 have contaminants of concern detected at significant concentrations at or very near the bottoms of the probeholes.

Summary of Observations that may Warrant Further Investigation

- Apparent elevated natural thorium concentrations were observed in several of the probeholes in the 741 Sludge study area, indicating a potential source of Th-228 that was not identified in the interim baseline risk assessment. Probehole 741-2 exhibits the highest observed concentrations of natural thorium at a depth of 12.0 ft and a concentration of 58.41 pCi/g. The elevated thorium in probehole 741-2 spans a depth range from approximately 8.0 ft to 17.0 ft. The elevated thorium is also present in probeholes 741-3, 741-6, 741-8, DU-7 and DU-8; however, the elevated thorium in DU-7 has been determined to be natural thorium (Th-232). It is important to note here that the mean background value for natural thorium in INEEL soils is 1.25 pCi/g (Rood et al. 1996).
- Enriched, or highly enriched uranium was identified in probeholes 741-6 and 741-9. These zones were identified at the bottoms of the probeholes, separate from any Am-241 or Np-237. Natural uranium or enriched uranium located far from the probe (see J.W. Mandler's observations and comments).
- Cesium-137 was identified in probehole 741-4 at a depth interval from 13.0 to 20.0 ft, with a maximum concentration of 139.4 pCi/g at a depth of 16.5 ft. It was determined that this is a true source of Cs-137, as discussed in J.W. Mandler's observations.
- Several probeholes in the 741 Sludge study area exhibit concentrations of Np-237 that indicate a source of separated Np-237, that is not associated with the decay of Am-241 originally disposed in the area.

Additional Type A Probe Installation Options

Based on the review and observations of the preliminary logging data provided by GTS Duratek, there are two possible options for the installation of additional Type A probes:

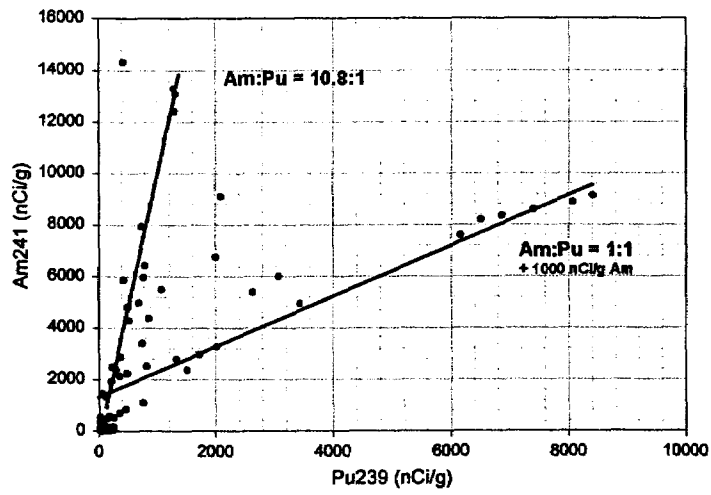
Install the 6 additional Type A probes in a ring, concentric with the probe of interest (i.e. DU-3). The spacing on the Type A probes should be a maximum of 2 ft, however the preferred spacing is 1.5 ft. These additional probes would be logged by GTS, with a detailed data review provided by INEEL personnel. Additionally, recommendations for azimuthal logging in the detailed probehole cluster would be provided. Analysis of general logging data and directional data by INEEL personnel would be provided to assist in the location of Type B probes.

Delay the installation of the additional Type A probes for the detailed probehole cluster until the azimuthal logging tool has been repaired. The azimuthal logging tool should be deployed, as detailed above. Upon analysis of the directional data by GTS and INEEL personnel, recommendations can be made for the installation of additional Type A probes. This method may eliminate installation of excessive probeholes, and minimize cost. After installation and logging of the additional Type A probes, a detailed analysis of the logging data will be performed with recommendations for additional azimuthal logging locations in the new probeholes. All of the data will then be analyzed by INEEL personnel, and recommendations for the location of Type B probes will be provided.

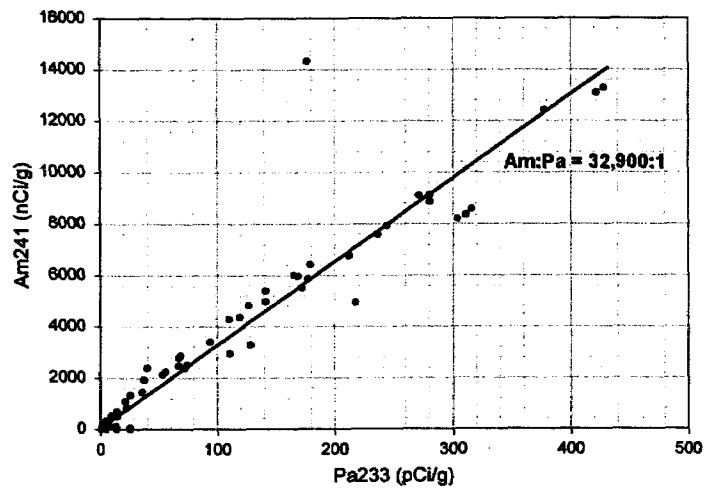
APPENDIX C

Gamma-ray ratio charts

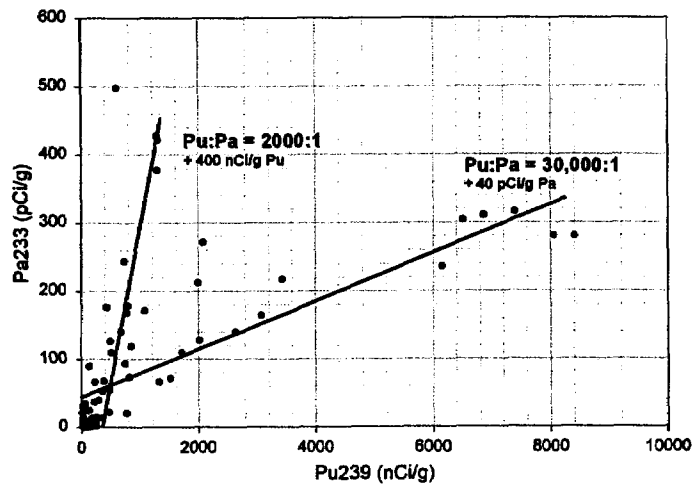
Am/Pu



Am/Pa



Pu/Pa



bmb

cc: Bruce H. Becker, MS 3920
Sven O. Magnuson, MS 2107
T. J. Meyer, MS 3920
Hopi Solomon, M-K
ARDC Files, MS 3922
J. R. Giles File
J. W. Mandler File

Uniform File Code: 6452

Disposition Authority: A23-1-a

Retention Schedule: Destroy when two years old or when no longer needed

NOTE: Original disposition authority, retention schedule, and Uniform Filing Code applied by the sender may not be appropriate for all recipients. Make adjustments as needed.

Appendix E

Evaluation of Geophysical Survey Data and Disposal Information to Support Selection of Type B Probe locations around Buried Stainless Steel at Soil Vault Row-12

Appendix E

Evaluation of Geophysical Survey Data and Disposal Information to Support Selection of Type B Probe Locations around Buried Stainless Steel at Soil Vault Row 12

Soil Vault Row 12 Type B Probe Placement

Nicholas E. Josten and Hopi Salomon

Irradiated stainless steel reactor components have the potential to disperse C-14 through corrosion processes and are the target for Type B probes in the vicinity of Soil Vault Row (SVR)-12. For this purpose, Type B probes are preferably installed in the immediate vicinity of a soil vault containing reactor components. Additional probes (vapor ports) are placed at progressively greater distances from the soil vault in order to evaluate contaminant mobility in the gas phase.

Historical records indicate 15 disposals were made at 10 separate locations along the east end of SVR-12. Seven of the disposal locations are thought to contain only irradiated stainless steel pieces (listed as originating from Generator Area CPP-603 in Table D-1). Records provide an approximate location for each disposal location relative to the east end row marker of SVR-12. Due to the approximate nature of the recorded positions and uncertainty regarding the east end marker location at the time of disposal, geophysical data were analyzed to support selection of a specific location to install Type B probes.

Table E-1. Disposal Information for east end of SVR-12.

Generator Area	Location*	Disposal date	Volume (m ³)	Weight (grams)
CPP-603	SVR12 + 10 ft	05-May-82	0.8213	544300
CPP-603	SVR12 + 10 ft	20-May-82	0.8213	544300
CPP-603	SVR12 + 20 ft	02-Jun-82	0.8213	544300
TRA647	SVR12 + 20 ft	04-Jun-82	0.8496	317500
TRA647	SVR12 + 33 ft	07-Jun-82	0.8496	317500
TRA647	SVR12 + 33 ft	08-Jun-82	0.8496	317500
TRA647	SVR12 + 44 ft	08-Jun-82	0.8496	317500
TRA647	SVR12 + 44 ft	09-Jun-82	0.8496	317500
CPP-603	SVR12 + 55 ft	21-Jun-82	0.8213	544300
CPP-603	SVR12 + 55 ft	30-Jun-82	0.8213	544300
CPP-603	SVR12 + 65 ft	30-Jun-82	0.8213	544300
CPP-603	SVR12 + 75 ft	08-Jul-82	0.8213	544300
CPP-603	SVR12 + 85 ft	13-Jul-82	0.8213	544300

CPP-603	SVR12 + 122 ft	21-Jul-82	0.8213	544300
CPP-603	SVR12 + 132 ft	28-Jul-82	0.8213	544300

* distance from east end of SVR-12

Figures E-1 and E-2 show high resolution magnetic and electromagnetic (EM) induction data for the area surrounding SVR-12. Highlights show anomalies that indicate the presence of buried metal objects along the trend of SVR-12. Figures E-1 and E-2 also show the recorded positions of the Table E-1 inventory items relative the current east end marker (this metal marker is visible as a clear geophysical anomaly in both the magnetic and EM data). The number and spacing of the combined magnetic and EM geophysical anomalies roughly correspond with the number and spacing of recorded disposals.^m In this analysis, the geophysical anomalies are interpreted to reflect the actual position of the disposals.

Figure E-3 shows a possible association between inventory items and geophysical anomalies. This interpretation is based on the assumption that the current east end marker has not moved since the waste was buried and recorded in 1982. In making this association, anomalies occurring well off the SVR-12 trend were attributed to Trench 41, with the exception of the anomaly labeled +10. Of particular interest are the group of waste recorded as disposed from +55 to + 85 ft, which are associated with a cluster of magnetic and EM anomalies occurring over a 40 ft interval. The +65 disposal was selected as a preferred target because it has both a magnetic and EM signature and because it falls near the middle of the interval of interest. Although the correlation between inventory and geophysics for this disposal group is imperfect, any one of the disposals within this interval constitutes an acceptable target for Type B probes. Even if the association of inventory and geophysics is off by 10 – 15 ft, the selected geophysical anomaly would most likely still be associated with an irradiated stainless steel item shipped from CPP-603.

Figure E-4 shows a detail of the selected target and the proposed Type B probe locations. The radially arranged vapor port probe locations are set at 4.0 ft, 8.6 ft., and 13.2 ft from the center of the targeted soil vault. The closest probes (the first bundle of vapor ports and the lysimeter bundle) are positioned to lie 2 ft outside the edge of a 2 ft radius object representing the assumed waste disposal. The next two radially arranged vapor port probes are at 140 cm (4.6 ft) and 2.80 m (9.2 ft) from first probe. This is similar to the approach proposed to monitor activated beryllium at SVR-20. The line of vapor port probes was chosen to lie as close to perpendicular to SVR-12 as possible but was skewed to avoid any contact with metallic waste in adjacent trenches. The tripled vapor port bundles should be placed such that the deepest is at refusal, the middle is completed approximately 3 ft closer to the surface and the upper is completed approximately 6 ft above refusal. This should insure that the targeted waste has the most complete sampling coverage possible. The lysimeter bundle, like the closest vapor ports are also arranged as close as possible to the targeted waste. The deep lysimeter should be completed at refusal. The upper lysimeter should be completed approximately 3 ft above refusal. Remaining probes, i.e. tensiometers, moisture and geochemical probes, are arranged with less specificity, but still relatively close to the source, with vertical completion determined in the field.

^m The highlighted anomalies vary in size and amplitude, suggesting that the associated metal objects vary in size, composition and/or burial depth. This observation conflicts with inventory records that show the east end soil waste disposals to have essentially uniform size and weight. Burial depth and composition were not recorded.

The proposed probe bundle coordinates are given in Table E-2. Probes used to collect physical samples (i.e., the lysimeters and vapor port probes) are to be arranged such that all probes within the bundle are installed as close as possible to being equidistant from the targeted waste.

Table E-2. Proposed Type B probe locations.

Probe Bundles	Easting *	Northing*
SVR-12 Target Disposal	267859.2	668447.4
SVR12-1-VP	267863.0	668449.9
SVR12-2-VP	267866.8	668452.5
SVR12-3-VP	267870.7	668455.0
SVR12-1-L	267858.2	668443.2
SVR12-1-T	267860.1	668440.9
SVR12-1-G	267859.5	668438.7
SVR12-1-M	26786105	668439.1

* Coordinates specified in Idaho State Plane, East Zone, NAD27

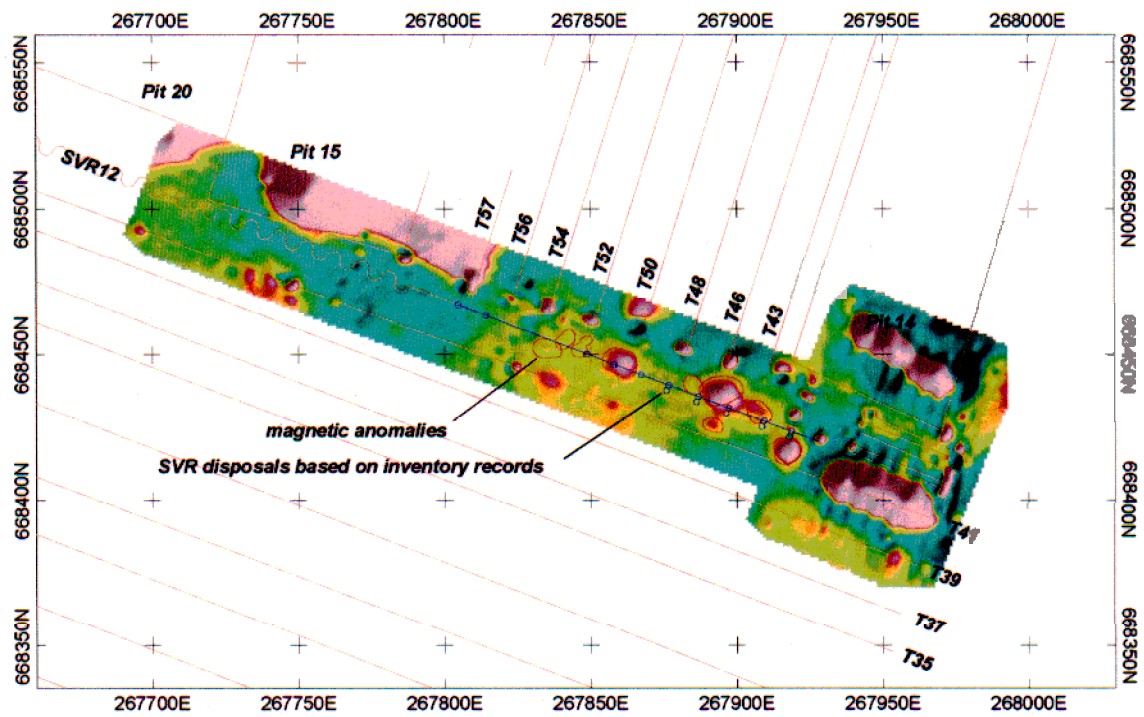


Figure E-1. Vertical gradient magnetic data for the area surrounding SVR-12.

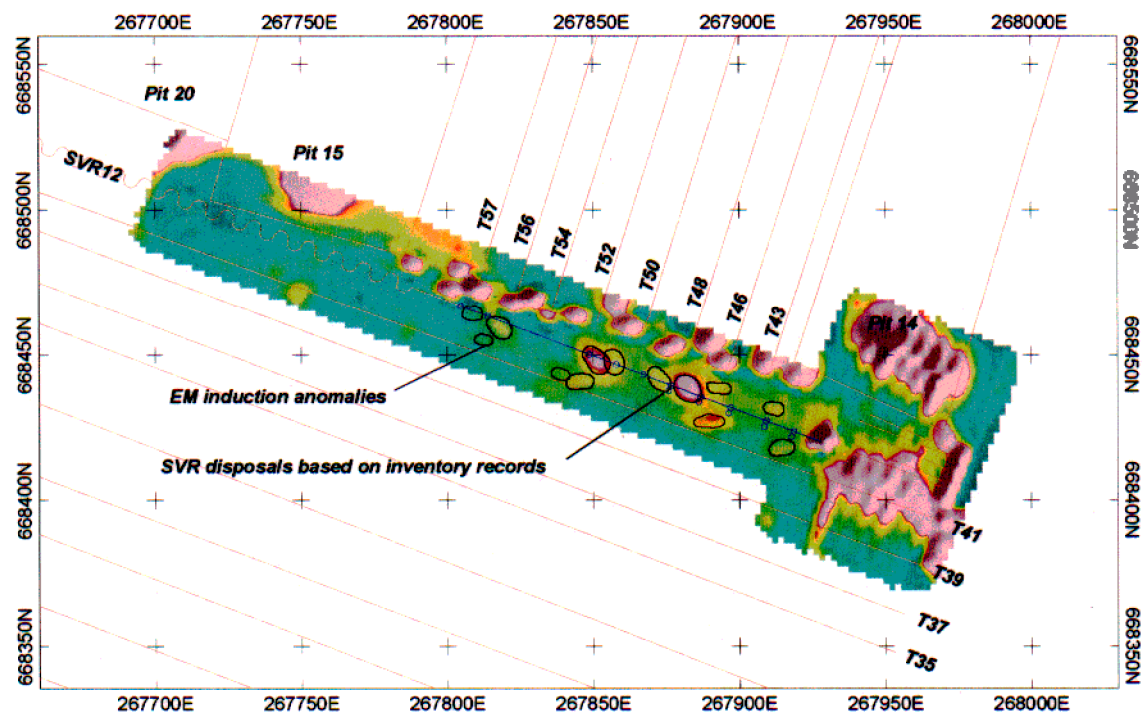


Figure E-2. EM induction data for the area surrounding SVR-12.

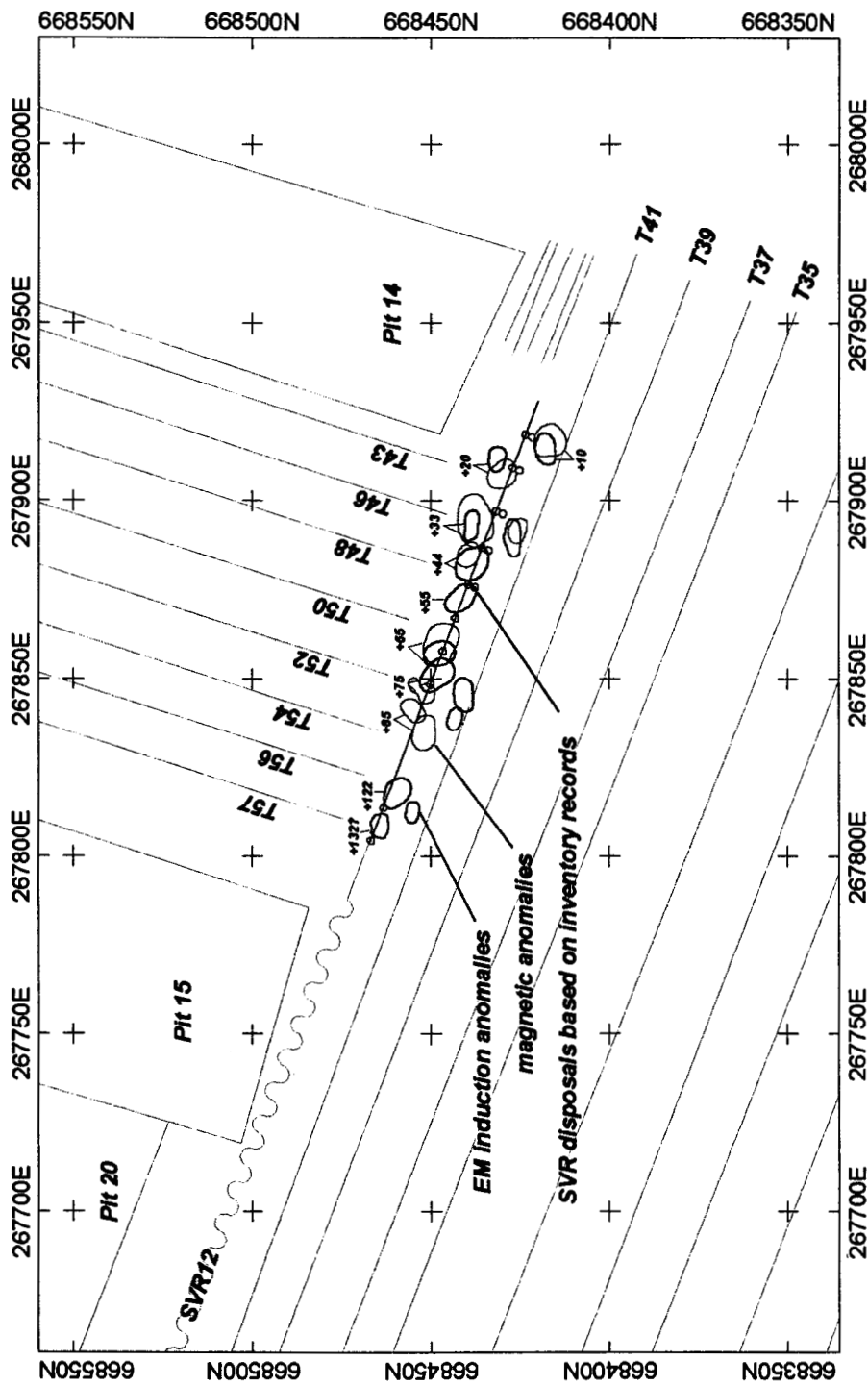


Figure E-3. Geophysical interpretation summary for SVR-12. Labeled anomalies are interpreted to correspond with specific inventory items, based on their position and spacing along the trenchline. Unlabeled anomalies are interpreted to represent objects within the adjacent Trench 41.

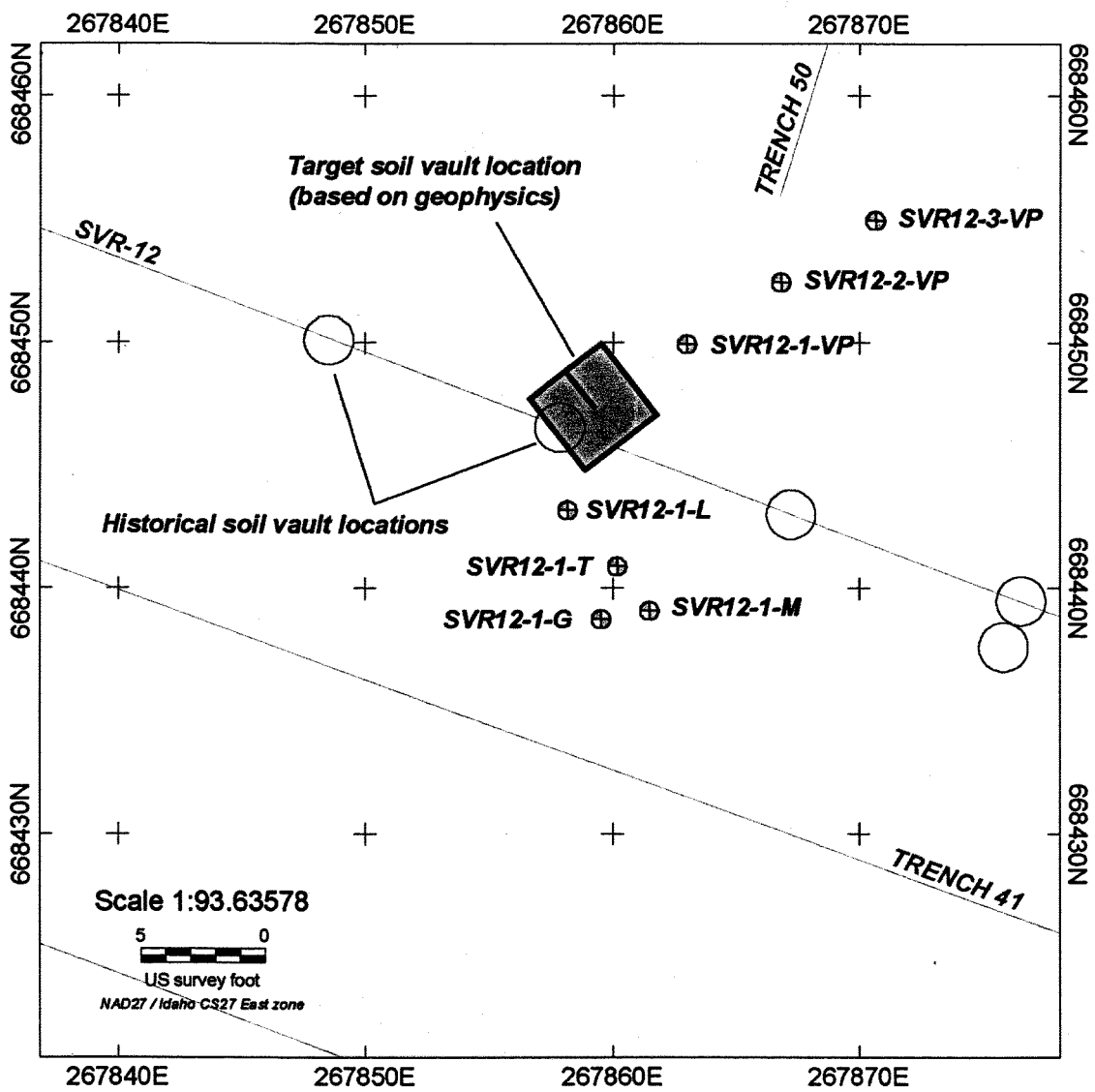


Figure E-4. Proposed location of SVR-12 Type B probe clusters.

